June/July 1988

AIR & SPACE

Smithsonian

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June/July 1988
Volume 3, Number 2

AIR & SPACE
Smithsonian

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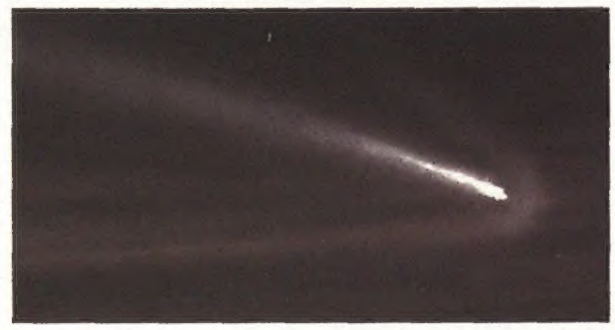

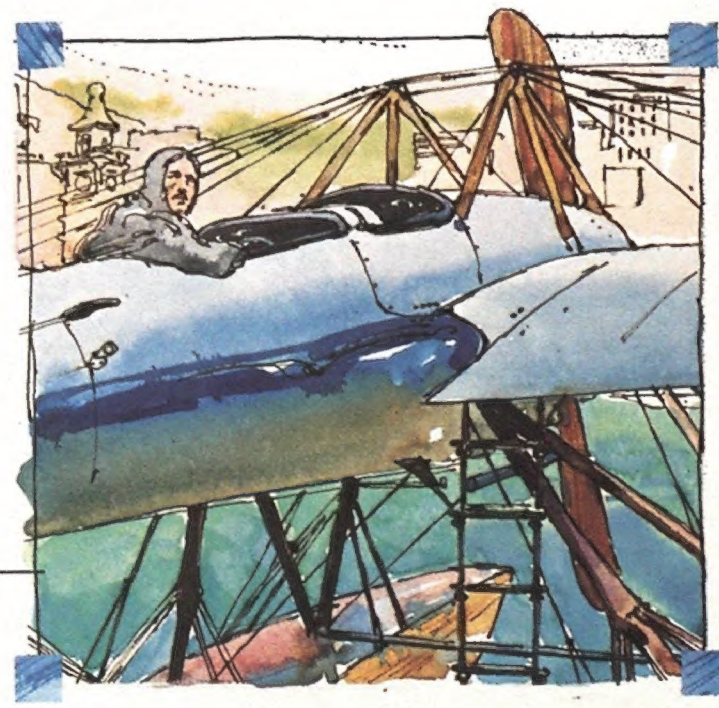

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Cover: *A Vega balloon probe bobs through the hostile atmosphere of Venus in this painting by Ron Miller.*

The Mission

When the Smithsonian Institution was founded in 1846, it was with a mandate for "the increase and diffusion of knowledge." Achieving that goal properly means reaching out to as many individuals and groups as possible. That is the idea behind the National Air and Space Museum's new Minority Outreach Program.

Studies show that if a child has not developed an interest in science and mathematics by the third or fourth grade, the prospect of the child doing so later will diminish over time. If that sounds disheartening, consider this: in the average elementary school classroom, less than 30 minutes per day are devoted to teaching science—hardly enough to stimulate and sustain a meaningful interest in the young student.

The long-term implications of these statistics are already being borne out in the nationwide decline in enrollment in college science and mathematics programs, as well as in the weakening of the United States' international position of leadership in the aerospace, science, and technology fields. Among most groups of minority students, this alarming trend is disproportionately evident.

The Museum's Minority Outreach Program is an effort to reverse this trend. Its primary goals are to increase minority children's interest in aerospace technology by encouraging their participation in the Museum's programs and exhibitions.

The program's efforts begin at the elementary school level. There, the program can make the most use of the young students' fascination with the aerospace field's activities and achievements, either by influencing a vision in those already interested or creating a vision in those with no previous interest.

We try to accomplish this goal in many ways. The first task is to visit the schools, armed with a lot of enthusiasm and an exciting presentation, including slides, materials from the collection, and information for teachers about the Museum's Education Resource Center. The center, open to teachers of all levels and disciplines, offers educational aerospace materials produced by the Museum, NASA, other government agencies, and private organizations. A tour of the Museum exhibitions follows the visit, with emphasis on those areas that deal with minority contributions.

The roles of blacks in the history of aviation, for example, is a story that is unfamiliar to most young people. We introduce this story in the classroom and reinforce it when the students visit the Museum. Once there, black youth see such displays as "Black Wings," which document the contributions of black pilots and astronauts.

While visits to such exhibitions are an important first step in providing vital role models for minority youth, the effort cannot stop there. Follow-up programs must be initiated to direct interested and talented youth toward careers in science. Programs currently in the planning stage include parent-child workshops, a publication about aerospace careers aimed at schoolchildren, and a film about science careers to be made available to educators. Other goals include getting funds to bus inner-city schoolchildren to the Museum and producing public service announcements for radio and television.

It is our hope that the Museum's Minority Outreach Program will inspire similar programs at museums that have yet to join our effort. We have a lot to gain from developing these young minds. Minority youth is a vast untapped pool of talent that has the potential to make major technological contributions to our society if properly inspired and educated.

If we can give minority children the confidence to join the ranks of the role models we provide for them and to realize their potential to make valuable contributions to their country, then we are well on our way to accomplishing our mission. And if we can help promote in these young children a sense of pride in their past and hope for their future, then we will know our mission is succeeding.

—M. Antoinette Amos heads the Museum's Minority Outreach Program.

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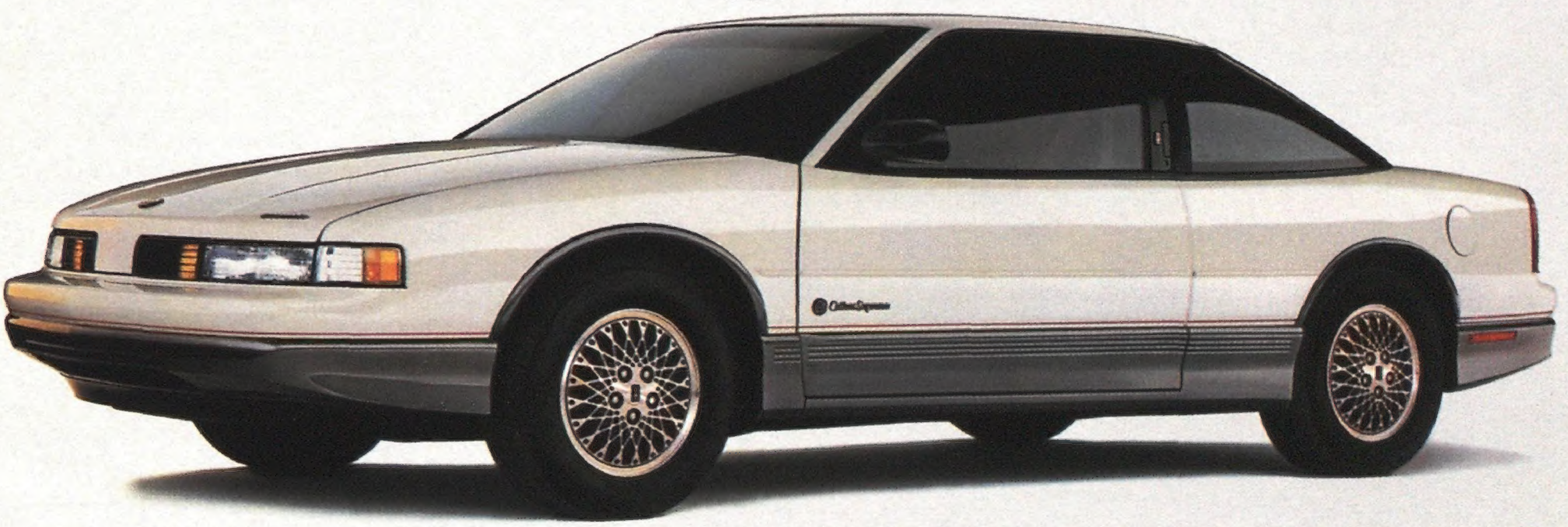

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Letters

No Resistance

John Logsdon's essay, "Resist the Pull of Mars" (April/May 1988), states that "a moon base is an essential stage of expansion beyond Earth." This is arguable and remains to be determined. It may be that a lunar base would be a useful place to practice or gain experience for our eventual exploration of Mars. However, it may not. The moon's gravity is half that of Mars and does not provide a similar workplace. The environment is very different—Mars has water, atmosphere, seasons, and weather; the moon has none. The moon is isolated, but we can easily simulate isolation on Earth. The moon's being three days away instead of 200 does not make for a very good simulation of Mars-like isolation. The really tough problems of getting ready for the trip to Mars (the interplanetary voyage, the long-duration human flight, and the aero-capture and propulsion technologies) will not at all be enhanced by going to the moon first.

Mars beckons; the role of the moon in our human exploration of the solar system remains to be determined. It may be that lunar activities fit within the Mars exploration program, but not until we organize that program will we find out. The current state of interest in U.S.-Soviet Mars exploration shows the interest that the world has in the two countries leading planet Earth in exploring Mars, the only other planet in the solar system that could support life—past or future. The debate should not be whether it is the moon or Mars, but how the Mars goal should be accomplished. If it is with the moon, then let's get on with it. But if it is not, then keep focused on the real target for humans in space.

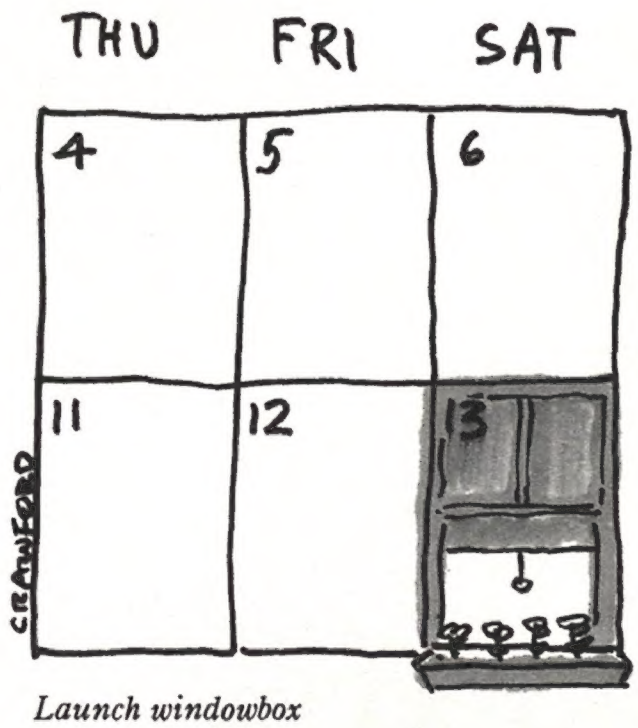
Louis Friedman, executive director of the Planetary Society in Pasadena, California

John Logsdon has concluded that the U.S. should first develop lunar settlements with a fair degree of self-sufficiency before beginning the development of similarly self-sufficient Martian settlements. This may eventually turn out to be true; however, we believe that presently it is premature to make such a judgment. Logsdon's case for settling the moon prior to Mars seems to rest on the assumptions that: a) it is easier and cheaper to develop largely self-sufficient settlements on the moon than to do so on Mars; b) if we first establish similar bases on the moon, it will then be easier to establish similar bases on Mars; and c) there are scientifically compelling reasons to go back to the moon.

Although these three assumptions may at first seem evident, in fact their validity is still in question, and current and future efforts by NASA to understand these issues are essential for a rational exploration.

We agree with Logsdon that sprinting to either Mars or the moon just to say we did it, without an overall long-term perspective on human presence in the solar system, is a major mistake.

Logsdon is a clear thinker on space exploration policy, and we agree with much of what he said. We also believe that if the decision to go to Mars or the moon next is to be made on technical grounds, more work is needed before we can make those technical judgments. If we are forced to make a decision at this point, our guess would be that Mars is both scientifically



Launch windowbox

much more interesting as well as being technically more feasible for a relatively self-sufficient settlement for humans.
Michael H. Sims
Christopher P. McKay
Moffett Field, California

Defenseless

T.A. Heppenheimer went overboard in his response to Irv Paskowitz (Letters, April/May 1988) by claiming military support for civilian development programs. I don't know about the 747, but the claim that "the Boeing 707 . . . [was] developed with heavy Pentagon support" is a statement in need of heavy support of its own. The Air Force would probably like to take credit now that the 707 has been established as a pivotal program in the advance of commercial aviation, but many who were there can contest his assertion. I was an engineering aide assigned to the 367-80 (Dash 80, the 707 prototype) in Boeing's Experimental Flight Test Center in 1955, and I remember the extraordinary measures taken by the Air Force to ensure no government funds or materials were involved in this totally civilian commercial program. Some time prior they had loaned some office furniture to Boeing, and at one point in the development of Dash 80, they actually turned all our desks and chairs upside down to inspect for "Government Property" markings. As far as I know they never found any, but even after Dash 80 became a test platform for systems destined for the military KC-135 we leaned over backward to avoid charging the Air Force for anything even partially based in the civilian program.
Kay J. Miner
Port Townsend, Washington

Manna From Heaven

What a memory I found pictured in Calendar for April/May 1988. The B-17 unloading a cargo of food over Holland with the big "J" on the tail came from the 390th Bombardment Group's airfield at Parham, near Framlingham in Suffolk.

I piloted a desk there from 1943 to 1945 as a cryptographer, receiving Distinguished Unit Citations that our air crews earned on some of the air war's roughest missions. When I read the orders for "Chow Hound," I arranged to hitch a ride—my only operational flight over the continent. The Dutch people who had suffered so much waved at us from the dikes.
James C. Hill
Atlanta, Georgia

Minus One Hawk

I studied "One Hundred Hawks For China" (April/May 1988) with great interest. I was hired personally by Bill Pawley in 1940 at the Alhambra airport during the recruitment program. It was my job to supervise the assembly of the 100 Hawks, though as the article stated, only 99 aircraft were assembled; one was dropped in the ocean during loading operations of a wing. It was my decision to reject this wing from flight because of saltwater corrosion in the aluminum structural parts.
Walter Pentecost
Hemet, California

A Piece Prize

In reference to "A Piece of History" (Soundings, April/May 1988), there are people around the United States with "legal" pieces of the *Challenger* and other orbiters. During the final selection for the Teacher in Space Project in Washington, D.C., the 113 finalists were presented with a flown tile from each of the shuttles, to be used for educational purposes only. I received a black tile from the right-hand Orbiting Maneuvering System pod of the *Challenger.*

I have since shown the tile to dozens of school and civic groups during my talk about the Teacher in Space Project. I did not expect the silent reverence of adults and children alike when I let them touch the tile.
William Townsend
Bar Harbor, Maine

Your piece in the April/May 1988 issue concerning the discovery of *Challenger* debris rekindled a question I have never heard answered. Why are the remains of the *Challenger* relegated to a hole in the ground?

As one of the fortunate few to see the *Challenger* remains in their reconstructed form at the Kennedy Space Center (prior to storage in the underground silos) I can tell you that the impact of a static display would be phenomenal.

The *Challenger* accident was a significant event in our still-fledgling evolution toward space exploration. Someday, when mankind resides on the moon or Mars, the only evidence of this event will be photos, because the remains of the *Challenger* will have become piles of rust in a forgotten hole.
C.G. Jenkins
Titusville, Florida

Flying the Pancake

Your article "When Pancakes Flew" (Oldies & Oddities, April/May 1988) stated that "the V-173 was modified to allow the pilot to sit up." This implies we had a prone couch ready, or flew with it installed, then reverted to a standard seat. Actually, we didn't get that far. After much experimenting with the prone concept in the mock-up, the concept was abandoned. It was too difficult to operate controls lying down, and the couch was uncomfortable after a short period. Charlie Zimmerman and I agreed, and it was never installed.

It is interesting to think about what might have transpired had we been able to complete the XF5U-1 airplane and get it into flight testing. Taxiing to the ramp that

day, and learning about the Bureau's directive, I felt like a big league hitter—bottom of the ninth, third out—watching his long fly grabbed at the fence. Charlie hid his feelings well, but I knew how he felt.
Boone Guyton
Woodbridge, Connecticut

"When Pancakes Flew" implies that Charles H. Zimmerman originated the flying wing concept. Not so. Proper credit belongs to Dr. Cloyd L. Snyder—a podiatrist! In 1926 he tossed a felt heel lift toward his desk and noticed that it glided. Intrigued, he developed the idea through models, and a man-carrying glider was flown in 1932. The glider was later powered and flew successfully. A corporation was formed and eventually evolved into the Arup Manufacturing Corporation.
Bob Lane
Cornwall, New York

Editor's reply: Zimmerman's contribution was the wing-propeller combination, which was directed quite specifically at addressing the problem of tip vortex formation. The Arup wing is strikingly similar to the Pancake but did not exploit multiple propellers.

A Favorite Aunt

In "Auntie Comes to Stay" (In the Museum, April/May 1988) you imply that the only Ju52s around are with the Swiss Army or used as bits in chicken houses. Tante D-AQUI, I think, is ruffling her feathers in vehement disagreement.

Last summer as I wandered in the Black Forest near Freiburg, I heard a rumble above me in the distance. The sound grew stronger and louder. A very slow and sedate old plane passed overhead. As she banked I noticed she had unusually old-fashioned, long, and graceful wings. She disappeared into the sunset and gradually her voice faded away.

Among thousands at the Freiburg Flugplatz I learned that the airplane, Ju52 D-AQUI, is named "Berlin-Templehof" in honor of the founding home of Lufthansa. This Tante Ju, flown by Lufthansa pilots (as a perk, I suppose), flies around the Federal Republic of Germany giving rides at airshows on weekends.
Alice Mansell
Atherton, California

First?

With reference to "That's Entertainment" (Soundings, April/May 1988), the performance by Craig Hosking of "the world's first inverted takeoff and landing" is not the first by any means. In 1939 at the National Air Races in Cleveland, tens of thousands of people, of which I was one, watched Mike Murphy do the trick in a small monoplane resembling a Buhl "Bull Pup" (built from parts of a wrecked E-2 Cub) with extra landing gear topside. I've also been told that it was done in Germany around 1912 by Hans Grade, using a specially built airplane.
Al Sammis
Conneaut, Ohio

Corrections

The diagram comparing the pitch controls of the F-16 and X-29 in "X-29" (April/May 1988) shows both airplanes rotating around their centers of gravity. In fact, the X-29 should have been shown *translating* upward and rotating only slightly, as the text described it. The fault is the editor's, not the illustrator's.

In the same article, the caption beneath the photograph of an electronics bay in the nose of the X-29 implies that the units shown are part of the flight control system. In fact, they are flight test instruments and equipment.

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A Breathtaking View

The scientific potential of the 10-meter visual and infrared telescope under construction at Hawaii's Keck Observatory leaves astronomers breathless. Unfortunately, the $87 million facility taking shape atop a dormant volcano has the same effect on its builders. Workers on the dome are having a hard time adjusting to the rarefied air at nearly 14,000 feet. "I've seen people turn green," says field engineer Casey Yanagihara. "You can get physically or mentally sick. I don't know what it is—headaches, blurred vision, loss of memory." Within a few days, most laborers adapt to working at an altitude where decreased air pressure cuts oxygen levels in the blood to 80 percent of those at sea level, but some have quit their jobs because they couldn't acclimate.

The desolate site was donated by the University of Hawaii as part of a scientific preserve. A consortium of the University of California and the California Institute of Technology, funded largely by a $70 million grant from the W.M. Keck Foundation, will own and operate the facility.

When the telescope acquires "first light" in January 1990, it will dwarf the Soviets' six-meter reflector, currently the world's largest telescope, and triple current capability. The air at the site is clean and dry, and there is relatively little interference from city lights, so scientists should make good progress in charting the formation of stars and the atmospheres of various planets.

But before all that, Jim Waldbauer, a construction superintendent, faces the more pedestrian challenge of hypoxia, which also hampers skiers, mountain climbers, and pilots. "There are days when your thinking isn't quite as clear as other days," says Waldbauer, who has worked on one of the eight other observatories on Mauna Kea. "Some adapt better than others." Waldbauer's two-pack-a-day habit increases his difficulties.

Yanagihara, who makes the three-hour trip from Hilo several times a week, classifies the symptoms of hypoxia as Mauna Kea Syndrome. "Anything you do wrong up here you got a good excuse for," he says. He uses a notebook and a tape recorder to jog his memory.

"Tasks that I set out to do on the mountaintop become much less important when I get there," says project scientist Jerry Nelson. "Somehow mentally I say, *Oh, gee, that really didn't matter very much. I'll do it tomorrow.* Only when I get off the mountain do I realize I didn't accomplish what I set out to do. It's a peculiar thing because you feel like you're okay, but you're not."

Bottled oxygen is available, but the most effective countermeasure has been housing workers in the lodge at the base station, located at a less taxing 9,200 feet. Yanagihara says this helps quite a bit. "Your efficiency goes up and your awareness is a lot better."

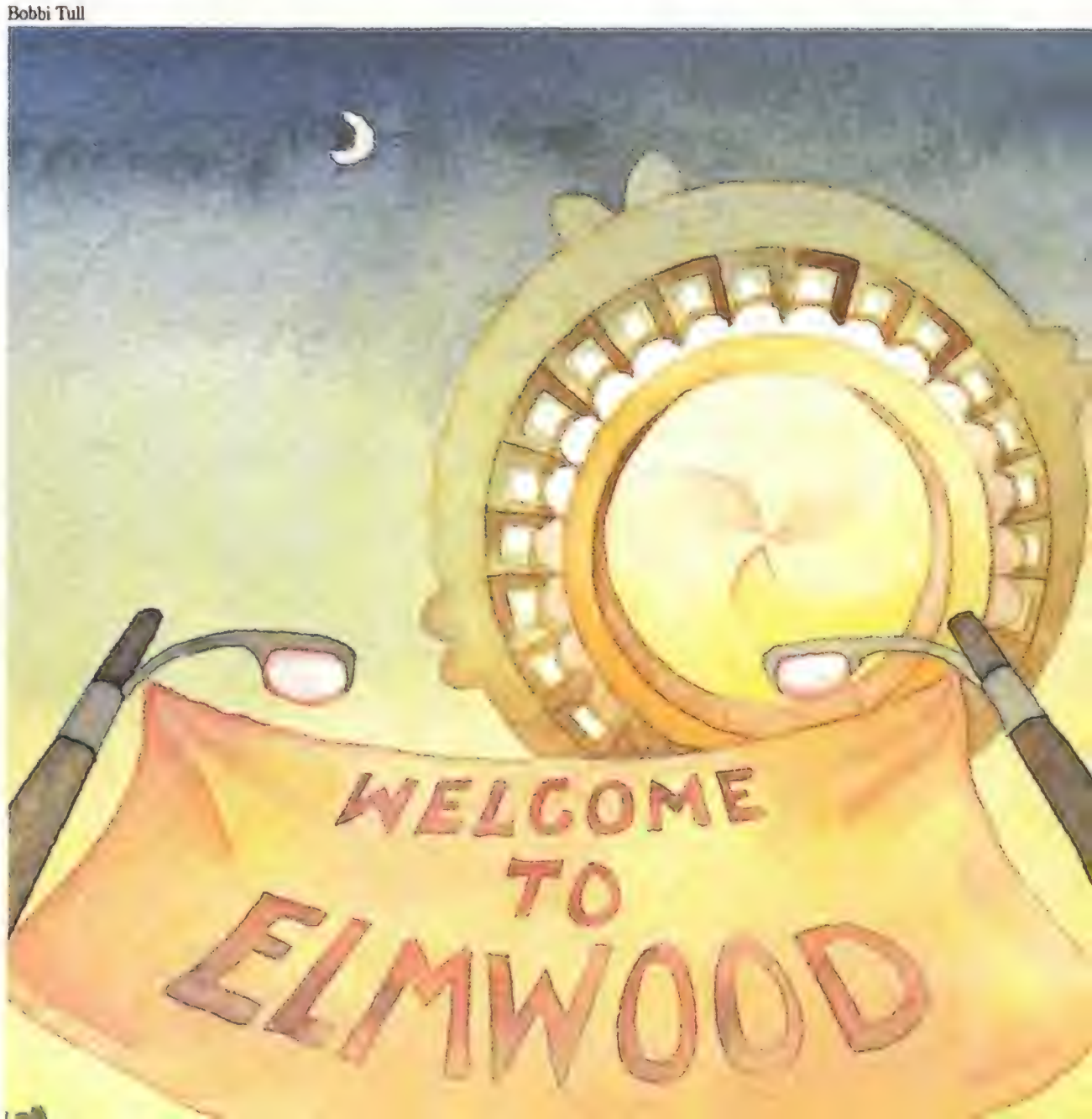
Scientists working at the completed observatory will have an easier time than the builders. The atmosphere in the control rooms will be maintained at levels approximating 9,000-foot elevations, roughly that of an airliner cabin at cruising altitude. Or researchers can linger in the observatory headquarters in the base station, where all data from the telescope will be fed by a microwave link.

—Bob McCafferty

Elmwood's Welcome Wagon

Thomas Weber is convinced that otherworldly beings are homing in on Chippewa Falls, Wisconsin. "In Elmwood, about 40 miles from here, there've been 30

Bobbi Tull



well-documented sightings," says the 50-year-old owner of a metal finishing business. "It's common conversation in Chippewa Falls. In fact, every year our civic celebration is called UFO Days." No matter that Weber has never seen a UFO. "Out there is a higher society," he says, "with a long-term plan for humanity."

Weber is leading a drive to welcome the visitors. He and four other residents have founded the Site Center Corporation, a nonprofit group intent on building a UFO landing strip in Elmwood. "We're talking about an approximate two square miles of secured property," he says, "completely bordered in lights. It would include offices for our organization, and a message—in picture form, based on the shape of the craft that's been spotted most often around here—meant to be interpreted by this higher society as meant for them. We're confident we'll be able to make it display humankind in a warm and welcoming manner."

That, he stresses, is the key idea. "Apparently this society is not going to force itself on us, based on how they've acted toward us so far," he says. "Since we're a society based on the golden rule, it seems as though we should give them an invitation."

Weber hopes the center will draw scientists from all over the world and become a base for UFO study. Meanwhile, he and the center's co-founders are seeking donations to get the anticipated $25 million project under way. "The only way we're taking donations is by the mail," Weber says. "If anyone comes knocking on your door saying they represent us, they don't.

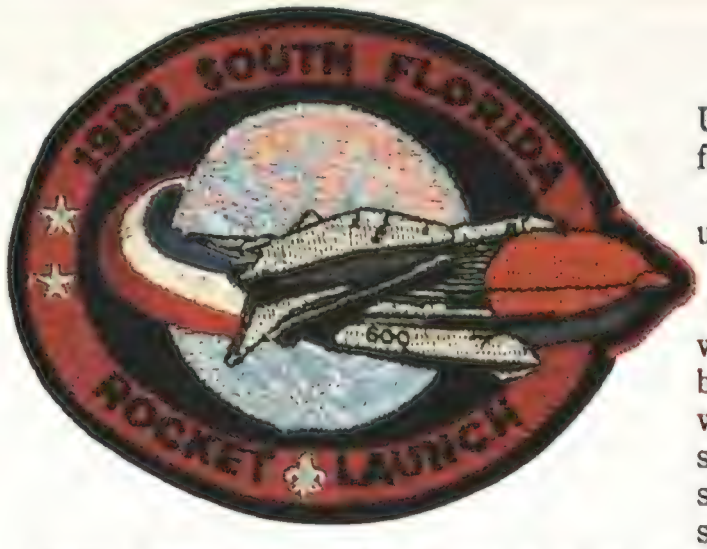
"We suspect that when we can build the center, in a very real way the whole world will be watching with us, whether they've contributed or not."

—*Michael Rozek*

Launch Date

Troops arriving at Air Glades Airport for the Southern Florida Boy Scout Model Rocket Competition last winter were directed by a large white rocket-shaped sign pointing the way off Route 27. The airport is just outside Clewiston, which lies on the southwest shore of Lake Okeechobee and is a popular stop for bass fisherman. Last February 12 and 13 the town provided a campsite for 25 Florida Boy Scout troops and a site for nearly 800 model rocket launches.

The man behind the third annual mass launching was David Anderson, scoutmaster for Clewiston's Troop 600 and a professor at the University of Florida. Tall and bespectacled, Anderson, 36,



looked the quintessential scoutmaster in his Smokey the Bear hat. He saw to it that the troops got settled in, that the preparations for the next day's barbecue were under way, that the local newspaper covered the event, and that the rockets were registered, launched, and judged without undue difficulty. Well seasoned by previous competitions, Anderson had brought a large toolbox stuffed with extra engines, parachutes, and other rocket paraphernalia. When one neophyte rocketeer brought in a rocket with no engine mount, Anderson helped him get it airworthy, then swapped some engines with him.

Registration commenced Friday night in the base tent, a large green military-style affair lit by Coleman lanterns and a few electric lamps. The judges carefully checked each entry for weak fins and shaky engine mounts and graded it on construction and appearance.

Saturday dawned sunny, cool, and windy as scouts and onlookers gathered near the runway. Launch pads had been set up on five large barrels, each holding eight rockets. After local Cub Scouts launched their small rockets, the Boy Scouts moved in with their models and the competition got started. Judges across the runway calculated altitude; another group tallied the scores. Winners would receive trophies and Estes rocket kits. The launches went on for the better part of the day, with occasional breaks to accommodate a local parachute club that stubbornly insisted on jumping over the launch site.

The scouts created rockets with a staggering variety of shapes, sizes, color schemes, and names. All built from kits, they ran the gamut from unpainted rush jobs to meticulously detailed miniatures. There were scale models of Redstones, V-2s, Nikes, SR-71 Blackbirds, even Jupiter-C rockets with tiny Explorer satellites perched on top. And there were more fanciful craft named Mean Machine, Mini Mean Machine, Marauder, Scorpion, Sizzler, and Rebel. One scout had carefully penned "The Ultimate Sin" in gothic script on the side of his entry. It was named, the owner said, after an Ozzy Osbourne album. And when its countdown ended, The Ultimate Sin committed just that: its engine failed to start.

There were a good number of failures; unlike Boy Scouts, model rockets aren't always obedient. Most problems were due to improper insertion of the wire igniters, which operate like the filaments in a light bulb. (Hitched to a battery, they heat up when the switch is thrown, igniting the solid propellant.) But there were also many successes, with the rockets hissing and sputtering off the pads and climbing as high as 3,200 feet.

Anderson made the most spectacular launch of all: a seven-foot monster provided by U.S. Rockets of Claremont, California. Displayed during registration, it had prompted the same question over and over: "You're going to launch *that?*" Launch it he did, with the help of members from a local rocket club, who had their own walkie-talkie headsets and hand-stitched parachutes for their rockets.

After the dust settled and the sun set, the barbecue flamed up. Among the diners were a few with stiff necks and sunburned faces.

—*Tom Huntington*

Making Money the Old-Fashioned Way

Kenneth Rawlings, founder and CEO of Otis Spunkmeyer, Inc., a California gourmet cookie company, flew from California to Missouri in a DC-3 in 1951, and to this day

Phil Jordan

he remembers the charm and excitement of his first flight. Several months ago, Rawlings bought a DC-3, named it *Sentimental Journeys,* and set about re-creating that magic—and making a buck. Today he is selling one-hour sightseeing tours of the San Francisco Bay area for $75 a pop. "I'm not even a plane nut," he says. "I'm a businessman and I saw an opportunity."

A young couple cuddles and gazes at the DC-3 parked at the ramp at Oakland International's north field. The copilot, in a safari hat, preflights the airplane, and a stewardess wearing bright red lipstick and a pillbox hat carries trays of goodies on board. A limousine delivers more passengers, who are ushered up the airstairs into the cabin.

The pilot revs the engines and the cabin seats vibrate like a coin-op bed in a cheesy motel. The DC-3 bucks like a mule as it taxies to the runway. After takeoff, faces that looked a little apprehensive now beam. The young lovers peer into each other's eyes.

On cue from the stewardess the 18 passengers unbuckle their seat belts and start wandering about the cabin while Dinah Shore's "Sentimental Journey" plays on the intercom. They run their hands over the wood trim and admire the lavatory, which is bigger than the galley. They check the view from every window, leaving a trail of purses and camera bags and getting in the way of the stews trying to serve a snack. They test each seat, reclining until almost horizontal, and are amazed they're not staring at the chin stubble of the passenger seated behind them.

Sentimental Journeys flies low—about 1,200 feet—and slow—150 mph. ("I'm glad we're not going to Hawaii," says a passenger. "It'd take awhile.") Pilot Bob Vilcheck also flies the company Learjet and says, "It's like getting out of a Ferrari and into a slow, comfortable old Rolls."

Too soon Vilcheck lands and taxies to the ramp. The passengers just sit. No one jumps up to be the first off or the first to grab a bag of Spunkmeyer's freshly baked cookies. Finally Vilcheck manages to coax everyone off so the next group can board.

Besides carrying passengers, *Sentimental Journeys* carries the name "Otis Spunkmeyer" on the underside of its wings. "It's a wonderful billboard for us," says Rawlings. The formula must be working: Otis Spunkmeyer, Inc. is outfitting a second DC-3 for tours. Rawlings hopes to expand to other West Coast cities eventually.

Meanwhile, it makes you wonder about future tours. Forty years from now, will some entrepreneur offer us the chance to be herded onto a vintage 747 so we can relive air travel of the 1980s? More importantly, would anybody want to go?

—Elaine de Man

The Best Little Planet in Texas

"Mom, Dad, I'm in space," the letter began. "As I lifted off I experienced the pull of gravity, but as I reached orbit I became weightless. It is wonderful. I want to stay up here forever . . . . P.S. The food is horrible."

It was one of many letters home from the Lincoln Elementary School's fifth grade class, which last January made a space voyage of sorts. For one week teachers covered the windows of the Corsicana, Texas classroom with dark gauze, smeared purple gel on the lights, and showed slides from the Mariner and Voyager missions. The students, wearing foil-covered papier-mâché helmets that made them look like silver basketballs with bodies, spent two hours a day fantasizing about life on Purple Planet X while synthesizer music provided un-Earthly background noise.

Catherine and George Cisneros, the San Antonio teachers hired by a local arts council to conduct the class, say many kids have misconceptions about space. Their program is designed to stimulate children's imaginations by demonstrating the vastness of space and the Earth's place in it.

"*Star Wars* and all those movies are great," says George Cisneros, "but we want the students to stop thinking about space as a battle zone and start thinking about it as a living space. Who knows? It may be where they're going to live someday."

The *Challenger* explosion and the death of schoolteacher Christa McAuliffe haunt some children. "It was ten seconds till takeoff," Julie Mitchell wrote. "Everyone was scared and quiet. You felt like you were alone at times and to see someone smile really helped . . . . We took off. I knew I was going to die so I shut my eyes and gritted my teeth and made it."

The students discussed what form of government and rules they would live by on Purple Planet X. Straight Zs in Space Surfing School, they decided, could win you a scholarship to the University of Pluto or Venus U. (Venus was second choice because of a scandal involving the spaceball team.)

The class felt that the program helped them view the darkness of space in a new light. "I saw Mars, Venus, and many other planets and stars and all of a sudden I noticed that the solar system was all so large and the earth was only a small part," noted Chad Combs.

Some, however, clung to sci-fi legends. Wrote Amy Allison, "I feel like Marshans are going to pop out at me."

—Phillip Swann

Sylvia Bonin

Yeah, But Who's Gonna Carry the Torch?

While the media gets ready to make the trek out to the '88 summer Olympics in South Korea, David Criswell is planning to attend the 2008 games in a more exotic locale—low Earth orbit.

Criswell, a San Diego aerospace engineer, first proposed Orbital City, a permanent Olympics site, at an aerospace engineering conference in Los Angeles last February. He envisions zero-G arenas for new sports such as weightless gymnastics and a large stadium that spins to create artificial gravity for swimmers and runners.

Criswell foresees Orbital City as the first in a group of nonterrestrial human habitats that would encourage popular interest in space, stimulate a demand for Earth-space transportation, and consequently reduce launch costs to levels that make large-scale space commercialization feasible. While conceding that space exploration no longer whips up the public frenzy it did in the Apollo years, he notes that the Olympics have grown in popularity, and suggests

A new air traffic control system for the Federal Aviation Administration will play a key role in helping to meet the growing demand for passenger air travel by making it vastly more efficient. The system is currently under competitive development by a team consisting of Hughes Aircraft Company; Sanders Associates, a unit of Lockheed; and Unisys. The system, called the Advanced Automation System (AAS), promises to be one of the largest real-time computer-controlled systems ever developed. Twenty-three regional air route traffic centers around the nation will receive new equipment, and new computers and automated displays will be installed in nearly 300 airport control towers. AAS will be capable of meeting air traffic control requirements well into the 21st century.

A new, body-stabilized satellite will satisfy high-power communications needs into the 21st century. Designated the HS 601, the satellite's sun-tracking solar arrays are covered with large area solar cells capable of generating up to 6,000 watts of power. Today's medium-sized satellites generate about 1,000 watts. The increase in power will allow the satellite to adapt to a wide range of applications, including full-motion videoconferencing, multiple-channel direct broadcasting, and very small aperture terminal (VSAT) networks. The HS 601, under development at Hughes, is expected to be ready for service in 1991.

A processor utilizing advanced microchips will offer processing power equal to 200,000 desktop personal computers. This new programmable signal processor (PSP) uses very large scale integrated (VLSI) circuits called gate arrays to pack this power into a 65-pound box, which measures just one cubic foot in volume. By comparison, these 200,000 personal computers would weigh roughly 3.4 million pounds, without any add-on memory cards, disk drives, or monitors. If stacked 20 units high, the 200,000 personal computers would fill a room approximately 144 x 120 feet. The PSP is being built by Hughes for the APG-70 radar system to be used aboard the U.S. Air Force F-15.

A single high-power microwave system will distribute 60 television channels in the San Francisco Bay area from one centrally located headend site. The 60-channel AML® high-power array, built by Hughes, will allow United Cable Television Company to interconnect San Francisco's East Bay, South Bay, and Peninsula areas. By using Hughes' AML microwave link, six communities will be served without the expense of hardline transportation trunks or duplicating headend equipment and building facilities. United will also cut operating costs by maintaining only one headend instead of six.

Hughes Ground Systems Group is applying its airspace management experience to the exciting challenges of worldwide air traffic control. These systems will be designed to ensure service 24 hours a day, 7 days a week. They will support distribution of processing among multiple computers linked via local area networks. The many challenges include design and development of hardware and software to support advanced display and man-machine interface technology, and using satellite technologies for future ATC applications. To help design the next generation of air traffic control systems, send your resume to Hughes Ground Systems Group, Employment Dept. S4, P.O. Box 4275, Fullerton, CA 92634. Equal opportunity employer. U.S. citizenship required.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

HUGHES
AIRCRAFT COMPANY

Subsidiary of GM Hughes Electronics

Phil Jordan

using that popularity to promote a cause more noble than car and computer sales. His timetable calls for an orbiting facility in place for the '08 games.

Criswell has done some number-crunching to determine the world's gross production figures early in the next century, and says an annual 0.8 percent global expenditure for Orbital City—paralleling the percentage of the gross national product the United States spent on the Apollo program during its peak—would yield $1.6 billion a year. The buck stops there: says Criswell, "This is basically a concept; there's no analysis behind it." And he does not intend to provide any, believing decisions about requirements and commitments should come from the citizens of Earth, Orbital City's ultimate users. "The last thing I want to be is a lone prophet," he says.

So far, that's precisely what he is. "I'm not saying we're ready to go right now," he admits, "but it's certainly worth looking at. It sure as heck is worth thinking big for a change." But even Criswell hasn't thought big enough to start negotiating with the television networks for broadcast rights. Not yet, anyway.

—Katie Janssen

The Road to Singapore

When the Republic of Singapore hosted its first international aerospace exhibition in 1982, industry moguls were decidedly unenthusiastic. Changi Airport was a bit makeshift compared with the posh ambiance of the Paris, Farnborough, and Hannover shows, and Asian Aerospace organizers planned no flying displays. Undaunted, the sponsors continued staging the event, attracting fair-sized crowds and a smattering of big-name exhibitors in 1984 and 1986.

Last year, the backers shifted into high gear. Declaring that Southeast Asia's premier seaport would be the site of a biennial aerospace exhibition to rival Paris, they began developing a $12 million permanent site. Such decisions can be made rather easily in the adolescent republic. Originally owned by the British East India Company, the island became a British Crown Colony after World War II and squirmed through a variety of political arrangements with its neighbors before claiming independence in 1965. Considered a somewhat authoritarian republic today, there is a good deal of healthy opposition in the government, but there is no disagreement about the goal of becoming the financial, marketing, and business center of the Pacific Rim.

Singapore's financial wizards have duly noted studies concluding that half the airliners to be built in the next 20 years will be bought by or serve Pacific Rim nations. The gurus also know that wherever airliners go, military and business aircraft and service and support concerns follow.

These pleasant prospects plus balmy weather helped spread a parasol of gaiety and excitement over the late January opening of the Fourth Asian Aerospace Exhibition and Conference. Dassault, Dornier, Fokker, Lockheed, Canadair, and other industry giants occupied exhibit booths. The visitor mix was just what the sponsors yearned for: a plenitude of subdued Western suits interspersed with green, blue, tan, and Clorox-white uniforms with splashes of battle ribbons. F-16 and Mirage 2000 fighters roared overhead and an Antonov AN-124 transport cast its giant shadow over the field in Asian Aerospace's first flying display. In the elegant chalets overlooking the Singapore Strait, kings and commoners mingled cheek by jowl with pashas and panjandrums, munching *foie gras* and eyeing the flying hardware. From time to time the press reported a crucial sale made, a deal cut.

As the three-day show drew to a close, its success became a source of pride for both the sponsors and the city, which has developed into a forest of highrise hotels, office buildings, and condos. But visitors who wandered off the palm-lined boulevards and spotless streets found remnants of the city's colonial past: a warm tangle of narrow streets lined with slightly soiled and faded buildings, shops below and above, flags of laundry waving on poles from every window. Dozens of tiny dens featured steaming seafood stews whose unorthodox appearance and pungent aroma startled Western palates. After all, one man's octopus is another man's hamburger.

—Robert B. Parke

Primary Concerns

Airline pilot Bill Horrigan knows he doesn't stand a chance of winning the Republican presidential nomination—not this year, anyway. The Woodbury, Connecticut resident didn't win a single delegate in the New Hampshire primary last March. But he did come in third—behind George Bush and Bob Dole, with 22 votes—in a straw poll at the Fruit and Deli Shop in Lancaster, New Hampshire.

Environmental concerns—particularly the hole in the Earth's ozone layer—prompted Horrigan, 46, to take a year off from United Airlines to organize his campaign. "There are many critical issues—drug abuse, AIDS, acid rain," he says, "but if someone asked me 'If you were president tomorrow, what's the first thing you'd do beside brush your teeth in the morning?' I'd say, 'Stop production of fluorocarbons and start a major campaign of planting trees.' " Trees capture carbon dioxide, he explains, the buildup of which is responsible for the greenhouse effect, which is raising global temperatures and sea levels as warming oceans expand and polar ice melts. He says the real problem will be intense and frequent storms and hurricanes spawned by a warmer climate. "People don't want to hear this stuff," Horrigan says. "They can't imagine a 25-foot wave approaching New York City." (The candidate has a flair for the dramatic seldom seen in fledgling politicians.) "But this is something that could happen if we don't do something about this now. I don't think we should fool around."

Before he began his campaign, Horrigan says he knew "if I wanted to make a fool of myself all I had to do was something like this." But once he came to grips with the idea of spending his own money to focus attention on environmental issues, "I figured, how can anyone be a fool by standing up and stating their case and trying to make a difference?"

The first officer returned to work last March, flying DC-10s on the New York-Honolulu route. Still smarting from the $70,000 out-of-pocket expenses for his New Hampshire bid, he says he will no longer spend his time off "tilting at windmills just trying to get in primaries. I'm going to continue to campaign, speaking wherever I go for whoever will listen, right up to November. More than that, I'm going to continue until the problems are solved."

—Peter Boody

Update

The first flight of the National Aerospace Plane ("The Hypersonic World of Robert Williams," February/March 1988) has been pushed back to at least 1994, due to a management shakeup and budget cuts. Program management has been transferred from the Defense Advanced Research Projects Agency to the Air Force two years earlier than planned to improve coordination of technology development and final fabrication. Defense department officials recently chastised DARPA X-30 technology manager Robert Williams for bypassing normal channels and writing to White House chief of staff Howard Baker last December to complain about the proposed 50 percent cut in program funding; though the cut has since been reduced to 20 percent, it will still slow development by at least a year.

American Airlines removed stainless steel spoons from its meal service last April ("The Deregulation Diet," April/May 1988), explaining that it will save $300,000 a year in cutlery handling and cleaning

Alan E. Cober

costs. Airline officials say in-flight desserts can be eaten with a fork and that stirrers are provided for coffee and tea. Miss Manners, take note.

The International Group for Historic Aircraft Recovery ("The Search for *L'Oiseau Blanc,*" February/March 1987) reported on March 10 that analysis of organic and metallic fragments discovered at an expedition site near Machias, Maine, reveals that all are man-made. One piece of organic material—possibly an anti-chafing substance—when reassembled, had the precise shape and dimensions of a wing rib from the French biplane *L'Oiseau Blanc,* which disappeared during a 1927 Paris-to-New York attempt. TIGHAR returned to the site this spring for its most painstaking search to date.

The Soviet Phobos-Deimos mission, scheduled for a July launch (Soundings, December 1987/January 1988), will carry a plaque commemorating the discovery of the two Martian moons by U.S. astronomer Asaph Hall, who spotted the satellites with a U.S. Naval Observatory telescope in 1877. Andrew Hyde, a descendant of Hall, proposed the idea to NASA after learning of the mission a year ago. Last March the Soviet Space Research Institute agreed to attach to one of the Phobos landers an aluminum plaque etched with the entry Hall made in his telescope logbook on the night of the discovery.

—Patricia Trenner

Anniversaries . . .

1752
June By flying a kite during a thunderstorm in Philadelphia, Benjamin Franklin proves his hypothesis that lightning is a natural discharge of electricity. Franklin used a silk kite for his risky undertaking. Mounted on top of the kite was a wire to draw the lightning down to the now-famous key. Franklin described the experiment in *The Pennsylvania Gazette*: "And when the Rain has wet the Kite and Twine, so that it can conduct the Electric Fire freely, you will find it stream out plentifully from the Key on the Approach of your Knuckle."

1783
June 4 Joseph and Jacques Montgolfier are the first to loft a hot-air balloon in public. Carrying no passengers, the 500-pound balloon ascended from Annonay, France, to a height of 3,000 feet and drifted a mile and a half before landing in a vineyard. A letter in a Paris newspaper reported: "The Montgolfiers have just performed a really curious spectacle here, that of a machine made of cloth . . . , which had the shape of a house. Peasants who saw it, frightened at first, believed it was the moon falling from the sky; they regarded this terrible phenomenon as the forerunner of Judgment Day."

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William Swan pleased Atlantic City crowds with his graceful rocket glider.

1931
June 4 Stunt pilot William G. Swan makes his first flight in a rocket-powered glider before a crowd of 2,000 in Atlantic City, New Jersey. After a push-off from his ground crew, Swan flipped the rocket ignition switch. For this test flight, he used only one of the glider's 10 rockets, each of which could produce 50 pounds of thrust. After climbing 100 feet and soaring 1,000 feet, Swan made a perfect landing.

June 16 A dedication ceremony for the Harding Tomb in Marion, Ohio, led by President Herbert Hoover, is repeatedly interrupted by the droning of several low-flying aircraft carrying photographers. An irate Hoover demanded that public examples be made of the pilots, so at his insistence the Department of Commerce mounted an investigation that resulted in temporary suspensions of the pilots' commercial licenses. Later, at the request of two Congressmen, the suspensions were overturned.

1933
June 27 Karl Jansky, the father of radio astronomy, presents a paper entitled "Electrical Disturbances of Extraterrestrial Origin" at an engineering convention in Chicago. The paper described Jansky's work at Bell Telephone Laboratories, where he used a rotating antenna to trace the atmospheric static that can interfere with telephone lines. Beginning in 1931, Jansky recorded static that registered as a steady hiss. In a letter to his family Jansky wrote, "I have taken more data which indicates definitely that the stuff, whatever it is, comes from something not only extraterrestrial, but from outside the solar system." Jansky later learned that the hiss was the sound of radio waves emanating from the Milky Way.

1957
July 12 Dwight D. Eisenhower becomes the first president to fly in a helicopter. He was participating in Operation Alert 1957, a civil defense exercise that included a mock nuclear attack. Eisenhower was whisked from the White House lawn to an undisclosed relocation center by an Air Force Bell UH-13J Ranger. Evacuated in other helicopters were key White House staffers and journalists. Millions of civilians in the northeastern United States took cover in air raid shelters.

Wide World Photos

The Dwight Flyer: Eisenhower made the first presidential helicopter flight.

1959
June 8 At Edwards Air Force Base the North American X-15, a hypersonic research vehicle, makes its first gliding flight. The rocket-powered X-15 was carried to 38,000 feet by a B-52 and then dropped; test pilot Scott Crossfield made a five-minute unpowered descent. The X-15 had a skin that could absorb and dissipate the extreme heat generated upon re-entry into the atmosphere, and carried instruments that measured speed and altitude above the atmosphere.

1971
July 16 Jeanne M. Holm becomes the Air Force's first female general. During her 33 years with the military, Holm opened the Reserve Officers Training Corps to women and was instrumental in lifting a restriction on the allowable number of enlisted women. Newspapers described Holm as a "pert blond" and a "pretty 50-year-old" when announcing her promotion.

1985
July 29 Carbonated beverages are launched into space. *Challenger* astronauts drank both Coke and Pepsi from specially designed cans during shuttle mission 51-F. The competition to design a can that could

Dale Hrabak/NASM

After shuttle mission 51-F, astronauts canned the consumption of colas in space.

safely dispense a carbonated beverage in space sparked a public relations skirmish between the two soft drink giants. Pepsi hailed the consumption of its product by shuttle astronauts as "one giant sip for mankind," but Coke's can performed better in dispensing a characteristic cola. Pepsi's container delivered a somewhat frothy drink. But because of the lack of refrigeration, neither soda won any points for taste. Said astronaut Gordon Fullerton, "Warm cola is not on anybody here's favorite list of things."

. . . and Events

June 3–5
National Biplane Fly-In. At Frank Phillips Field, Bartlesville, OK, (918) 742-7311.

June 4
Top Gun '88 Rocket Drag Races. The world's first elimination rocket drag racing competition. Prizes and party afterwards. At NASA/Houston Rocket Club, Houston, TX, (713) 486-6659 (evenings).

June 14–19
Aerospace America '88 Air Show, and First International Young Astronauts Conference. Oklahoma City Chamber of Commerce. This year's theme is "Peace Through Space." X-15 test pilot Scott Crossfield will speak on the history of experimental aircraft. At Will Rogers World Airport, Oklahoma City, OK, (405) 848-8513.

June 16–18
American Helicopter Society 44th Annual Forum and Technology Display. More than 90 technical presentations on topics from aerodynamics to military operations, including the Bell/Boeing V-22 tilt-rotor aircraft. At Sheraton-Washington, Washington, DC, (703) 684-6777.

June 18
"Exploring the Planets," Smithsonian Traveling Exhibition. At California Museum of Science and Industry, Los Angeles, CA, (213) 744-7400.

June 20–24
"Exploring the Heavens and the Earth—Past and Present." Four-day seminar. At Appalachian State University, Boone, NC. Smithsonian National Associates, (202) 357-1350.

June 25 & 26
Indiana International Air Show. Demonstrations by World War II aircraft and a Soviet MiG-15, comedy by Acme Duck & Airshow Company. At Mt. Comfort Airport, Indianapolis, IN, (317) 243-6587.

June 29–July 2
Universe '88 astronomy symposium. Astronomical Society of the Pacific and Royal Astronomical Society of Canada. Lectures, exhibits, seminars, and tours. At University of Victoria, Victoria, British Columbia, Canada, (604) 721-8465.

July 9 & 10
Flight Fest. Annual national model rocket competition. At Space Center, Alamogordo, NM, (505) 437-2840.

Rocketeers at Top Gun '88 will launch "Mach-buster" models.

Richard Bermudez

July 14
"Living and Working in Space," lecture by Derek Elliott, National Air and Space Museum. At Reuben H. Fleet Space Theater and Science Center, San Diego, CA. Smithsonian National Associates, (202) 357-1350.

July 15–17
Emerald City Flight Festival. Aircraft displays, including a British Spitfire and a Soviet MiG-15, and helicopter rides. At Museum of Flight, Boeing Field, Seattle, WA, (206) 764-5700.

July 16
"Early Flight: From Antiquity to the Wright Brothers," seminar by Peter Jakab, National Air and Space Museum. At San Diego Aero-Space Museum, Inc., San Diego, CA. Smithsonian National Associates, (202) 357-1350.

July 21–24
Dayton Air and Trade Show. At Dayton International Airport, Vandalia, OH, (513) 898-5901.

July 23 & 24
Central New York International Air Show. Warbirds competition and Coors Silver Bullet jet. At Oswego County Airport, Fulton, New York, (315) 349-8385.

Caroline Sheen

Imaginations and designs run wild at Oshkosh.

July 29–August 5
36th Annual Experimental Aircraft Association International Fly-In Convention and Sport Aviation Exhibition. Highlights include Concorde rides and an appearance by Neil Armstrong. At Wittman Airfield, Oshkosh, WI, (414) 426-4800.

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *National Air and Space Museum, Washington, DC 20560. Events will be listed as space allows.*

—Diane Tedeschi

Reading Between the Lines

A light and friendly biography, *The Wright Brothers* brims with family anecdotes, stories of childhood mischief, and tales of the trials and tribulations Orville and Wilbur faced in pursuit of flight. Written by journalist Fred C. Kelly, the 1943 book is the Wrights' official biography. Undoubtedly thousands of copies were published, but only one is special enough to be housed in the National Air and Space Museum's rare book and manuscript room. It is shown by appointment only.

Over 1,000 signatures of aviation's greats and near-greats crowd the margins of the book's 340 pages, including those of Charles Lindbergh, Chuck Yeager, Paul Tibbets, Eddie Rickenbacker, Donald Douglas, and Jacqueline Cochran, as well as Orville Wright himself (Wilbur had died before the book was published).

The book is the product of a quest by George A. Page, a draftsman, pilot, and aeronautical engineer whose career spanned the years from aviation's infancy to the Space Age. For nearly 30 years Page directed the design and engineering activities of Curtiss-Wright; he devoted another 20 years to Aeronca Aircraft after Curtiss-Wright's Ohio plant closed in 1951. His most famous designs include the C-46 Commando, the Curtiss Condor, and the Curtiss Hawk series. After he died in 1983 at age 91, the biography turned up among a modest collection of books and artifacts he bequeathed to the Museum.

Page collected the signatures for an estimated 30 years, taking the book with him on many of his travels. "He took it to dinners, industrial meetings, on trips—everywhere he thought he could add to it," recalls friend and Aeronca colleague John Houser. In his retirement years he frequently collected signatures at annual meetings of aviation organizations he belonged to, including the Early Birds, a club for those who soloed before December 17, 1917, and the Quiet Birdmen, the members of which are all experienced pilots who meet periodically, mostly to socialize. When personal contact was impossible, he would simply mail the book to a prospective signer, even after it had been filled with valuable signatures.

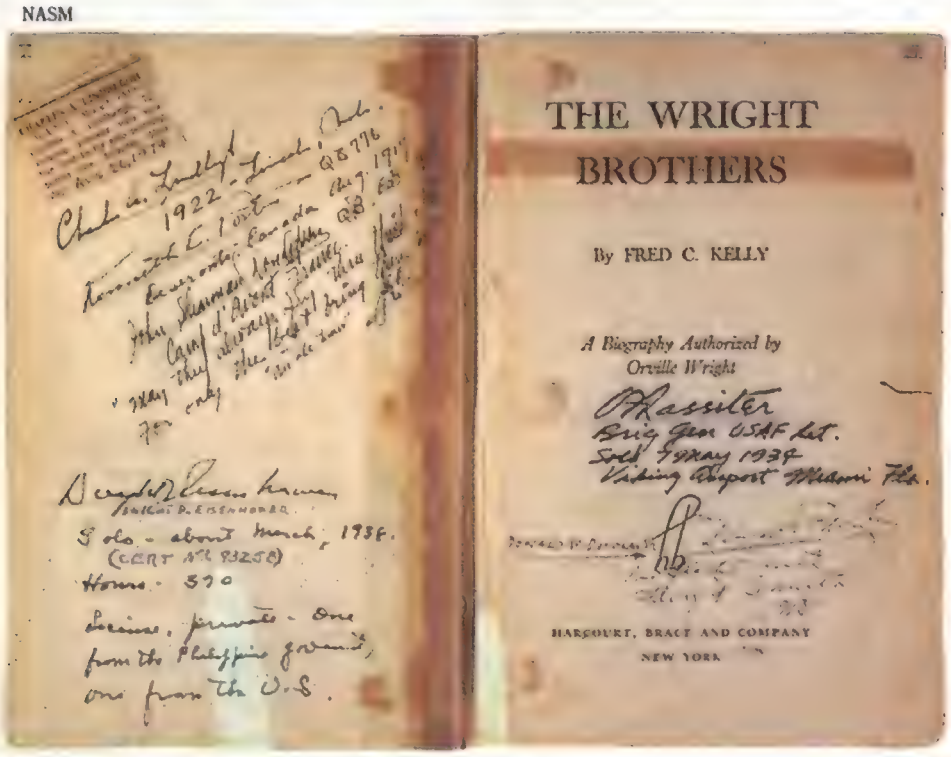
Not surprisingly, the inspiration for the project was Orville Wright. On May 19, 1945, Page wrote a letter to aircraft manufacturer Grover Loening, who had been an assistant engineer to Wright in 1913. "I have been thinking for some time that, if possible, I would like to get the autograph of Mr. Orville Wright in some book of Wright Brothers history of which he would approve," he wrote. "Knowing your close friendship with Mr. Wright and your understanding of his feelings in such matters, I am taking the liberty of asking if you would be so kind as to advise me how to proceed in this matter."

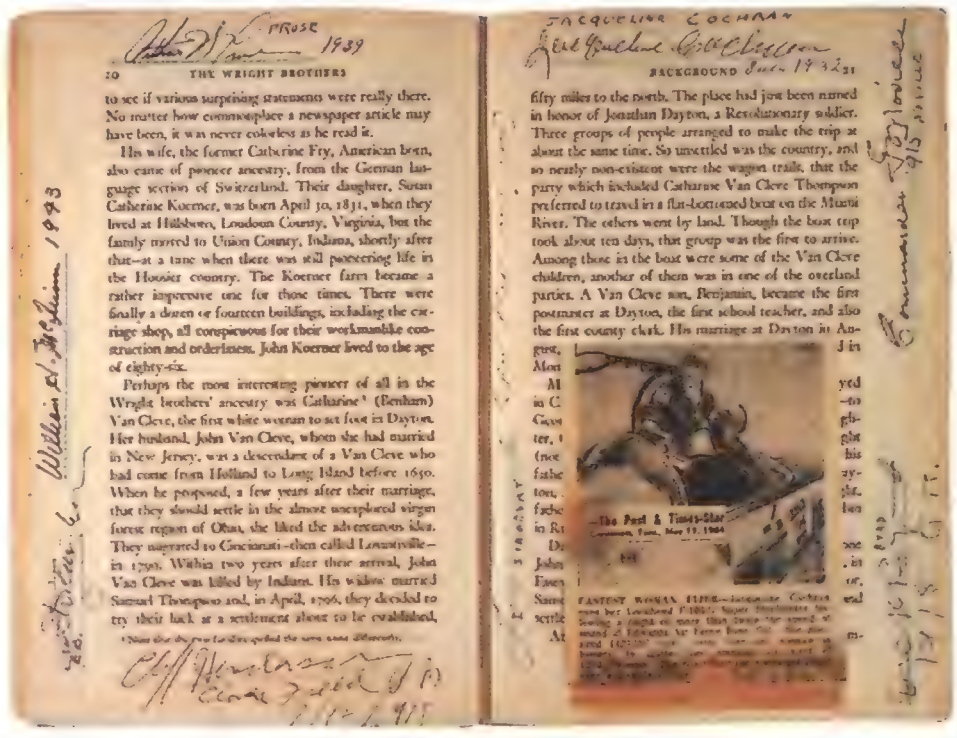
Replied Loening: "I would suggest that you get a copy of Fred Kelly's book on the Wright Brothers, which Orville approves of, and I am sure he would be delighted to autograph it for you."

Page's collection eventually extended beyond well-known aviators. "He was interested in acquiring signatures of anyone with a pilot's license," Houser says. Ruth Young signed on as the "first blonde and mother to go through the sound barrier, September 20, 1956." W.D. Leggett "saw the Right Plane [*sic*] being set up on Kill Devil Hill." G. Tiny Broadwick called herself an "early girl parachutist." Pilot Ralph Upson wrote, "Orville Wright taught me to fly in Apr. 1911. Had it not been for his instruction I would be dead today." Mervin (Ray) Roland listed his solo dates as "illegal 1928 - Waco 9; legal 1933 - *square* Cub." Louis Blériot's nephew and Orville

For 30 years, George Page filled his worn book with aviators' signatures.

NASM





NASM

Relegated to a spot beside the Mohawk, Mihalcea (far left) stood proudly.

Wright's grand-nephew also signed.

Page's motivations for acquiring the collection are unknown, and he kept the project to himself, sharing it with only a few close friends. One of them, Charles Pretzman, says Page was not an autograph collector in a broad sense. "He was a very private man—kind of a loner. His life was entirely consumed by airplanes and the air industry."

One thing is certain: Page had long intended the book to become part of the Museum library's collection. A piece of paper he inserted in the book instructing his signers on procedure begins, "Signature - Legible - Please," and ends, "Please note that this book is destined for the Air and Space Museum of the Smithsonian Institution . . . ." True to his word, it rests here today, a moving record of a lifelong fascination with flight.

—Monica L. Knudsen

One Day in Romania

The whirl of attention was familiar to the aviator, if the location was not. Short of fuel, Charles Lindbergh had landed his Miles Mohawk at a Romanian airport. He seemed puzzled as he glanced out at the crowd, according to a Romanian mechanic in attendance. "Then," the mechanic later wrote, "some Romanian aviators spoke to him, saying, 'This is Romania,' pointing to their hearts and to the earth to show him where he had landed."

For Lindbergh, it was but another day among many far more memorable. For Constantin Mihalcea, the Romanian mechanic, it became the memory of a lifetime. The four photographs he saved from that day some 50 years ago have the look of well-loved keepsakes: slightly yellowed and creased, their edges rounded from handling.

Early this year, Mihalcea, now retired and living in Bucharest, decided to part with the photographs. He wrapped them in a four-page letter explaining his intent and placed them in a flimsy envelope addressed to the President of the United States.

"I don't ask anything of you, Mr. President, of powerful America," Mihalcea wrote, "other than to accept these four photographs, which I consider unique." In keeping with Mihalcea's wish that the photographs be given an appropriate home, they found their way from the Voice of America's Romanian Service to the Museum, where Deputy Director Donald S. Lopez formally accepted them last March 18.

The former mechanic was uncertain about the date of the event he had witnessed. On the back of one of the photographs he had written "June 1936?" Actually, the visit most likely occurred on August 31, 1938. Returning to England from Moscow, Lindbergh and his wife Anne landed at an airport he said was in Cluj, a region near the Someseni, Transylvania airport where Mihalcea was employed. "There was an air tour on the field at Cluj," Lindbergh recalled in his wartime journals, "and the planes were taking off when we arrived. Press and photographers on the field. People crowded around, wanted autographs, interviews, etc. We finally drove to the military side of the aerodrome, and I taxied the plane over later for refueling. Very difficult to do anything because of excitement on field, but much better on military side. Always have to be more careful when people are excited. They run past the propeller, push against the wings, and forget almost everything that it is necessary to remember in operating aircraft. Whenever people get excited, you can expect accidents and trouble. I would rather do almost anything than land on a crowded aerodrome."

Despite the commotion, Lindbergh reacted with his usual grace. Mihalcea had been put in charge of cleaning the Mohawk's oil filter, changing the oil, and refilling the gas tanks ("with 92 octane," he noted). In appreciation, Lindbergh urged Mihalcea to stand beside him when the time to take photos came. "But it wasn't possible," the retired mechanic says. The inspector of state security stepped in to organize the pose, and the famed Romanian aviator Alexandru Cernescu wound up getting the coveted spot next to Lindbergh. "I consider that my rightful place was next to the plane," Mihalcea graciously conceded. "That was normal."

Although the visit was not historically significant in itself, the photographs and the letter have filled a gap in the Museum's Lindbergh biographical file, and "in that respect they certainly have historical significance," says aeronautics curator Claudia Oakes. "I think the whole story is really very charming, and once again points up Lindbergh's common-man touch and why everybody loved him."

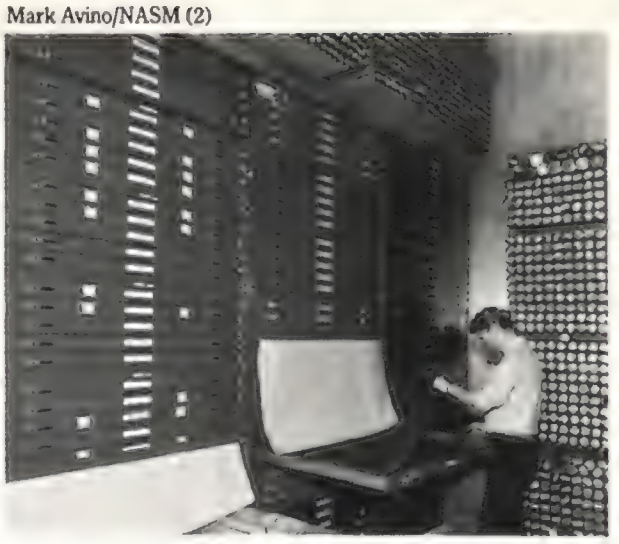
One person who undoubtedly welcomes the find is Louis Casey, who retired as aeronautics curator for the Museum in 1980. Casey had long had an interest in Lindbergh's specially designed Miles Mohawk, and kept an eye on its whereabouts for over a decade. Now, asked about the airplane's location, Casey crisply responds, "It's in my garage."

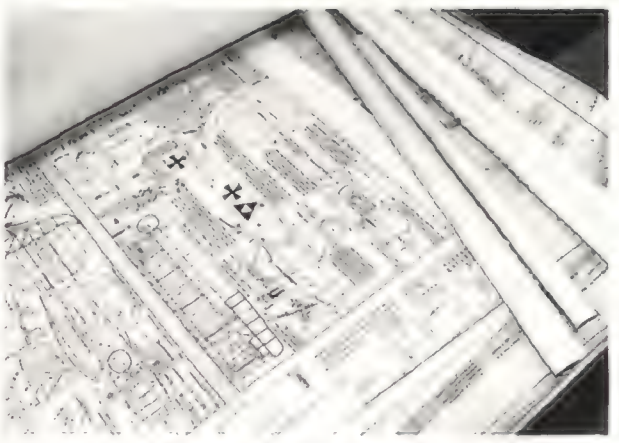
Casey acquired the two-seater monoplane—which has a 1,400-mile range—about five years ago, and has been trying to assemble a history of the airplane while restoring it for eventual donation to a museum.

Sometimes his information came from unexpected sources. One day, shortly after Casey acquired the Mohawk from a defunct Orlando, Florida museum, a retiree living in Florida approached him with a photograph in hand. Like Mihalcea, the man was a former mechanic who had witnessed a Lindbergh visit and still cherished the memory. But he had even more than that in common with Mihalcea. His yellowed photograph showed the Mohawk, then still sleek and new, at a crowded airport in Romania.

—Karen Jensen

Mark Avino/NASM (2)





Floor-to-ceiling storage units house the NASM archives' vast document collection.

Some volunteers will help index fragile aircraft construction drawings.

Share the Fantasy

Rows of shelves dominate the cavernous room. Thirteen feet high, they are loaded with scrolls and boxes. The air is dry, stuffy, and—thanks to round-the-clock refrigeration—never much above or below 70 degrees Fahrenheit.

To the uninitiated, this windowless warehouse, known to insiders as Building 12, might seem a desolate place to work. But to the people who oversee the thousands of uncataloged aviation and space documents, drawings, and photographs housed at the Smithsonian's Archival Support Center, working here is not just a job, it's an adventure.

The Museum has one of the largest and most valuable collections of aviation and space archives in the world, with material coming in daily from the military, aerospace companies, and the public. Donations are then sorted and sent for storage at either Building 12, part of the Museum's Paul E. Garber Facility in Suitland, Maryland, or the Museum itself.

Since material comes in faster than it can be examined and cataloged, a large portion of the archives remains uncharted territory, which makes the thrill of discovery a common experience for Museum archivists. "When I first came here I found autographed publications by not Orville Wright but by Wilbur Wright, which are very rare," remembers Pete Suthard, the Museum's head of information management.

Those who've dreamed of making such discoveries now have a chance. For two weeks this summer—July 31 through August 12—the public is invited to participate in "Air and Space Archival Treasures," a research expedition sponsored by the Smithsonian National Associates Program. Fifteen volunteers, who will each pay a tax-deductible $1,200 to participate, are being sought to work at Building 12 and at the Museum's archives, spending one week at each location. "They will be getting hands-on experience doing the same things that we do," Suthard says.

Volunteers assisting film archivist Mark Taylor should have a good opportunity for discovery. Of the Museum's 6,000 films, only 2,400 have been cataloged. Participants will view uncataloged films on a Steenbeck editing table, then research and write a description of the film for entry in a computer database.

Taylor emphasizes that a person need not be an aircraft historian to research the films, but should have a good visual memory. A viewer must watch a film and then remember the images long enough to later identify them in an aircraft reference book.

The breadth of the film collection is immense. Taylor recalls a film entitled *30 Minutes to Live,* which had only this brief description: "Good carrier shots, lots of neat footage." It turned out to be a 1960s film by Alexander de Seversky, a Russian immigrant who designed the P-47 prototype. The film urged Americans to build bomb shelters against Soviet ICBMs, which can reach the United States in 30 minutes.

Volunteers will also become acquainted with aircraft construction drawings stored at Building 12. Records from the Waco Aircraft Company, a manufacturer from aviation's golden age, are frequently requested by people restoring antique aircraft or building replicas. But because many of the drawings are too fragile to be handled, they are not yet accessible. Some participants will help ready the collections for use by indexing them so they can be microfilmed and cataloged. A person need not be an aeronautical engineer to help, since the necessary information is in the title block at the lower right-hand corner of each drawing.

Even non-buffs will find the artistry of these historic drawings impressive. "They're construction drawings for an airplane, but they're works of art," says Susan Ewing, a Building 12 archivist.

The program's organizers are excited about its dual benefits. While sharing the

richness of the Museum's archives, the volunteers will be making more of its collection available to future researchers. As Ewing says, "I just want to be able to fix it and make it ready and call people in and say, 'Use this, write books, make movies—use this!' "

Applications for the program are being accepted until July 25. For more information, call (202) 357-1350.

—Diane Tedeschi

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

Summer hours. Until Labor Day, the Museum is open daily from 10 a.m. to 9 p.m.

Thursday evenings. "Fly by Night" program: free activities for the whole family, including aerospace-related tours, demonstrations, lectures, and games. June 2–August 25, 6–9 p.m.

Summer Concert Series. Free concerts by U.S. military music ensembles; selected weekdays on the west terrace, noon to 1 p.m. **Commodores**—Navy jazz, Fridays in June and July 1, 8, and 15. **Country Current**—Navy country, June 9, 16, 23, and 30; July 7, 21, and 28. **Airmen of Note**—Air Force jazz, June 22 and July 20. **Spectrum**—Air Force rock, June 29 and July 27. **Army Blues**—June 7, 21, and 28.

Photography Contest. The Museum's "Focus on Flight" is open to amateur photographers of all ages. Cash and other prizes awarded. Entries will be accepted from June 1 to August 31; no entry fee. Call (202) 357-2700 for an entry brochure.

June 4 Monthly Sky Lecture: "Probing the Day Star." Illustrated lecture on the sun, including safe viewing by telescope (weather permitting). Geoffrey R. Chester, NASM. Einstein Planetarium, 9:30 a.m.

June 15 Exploring Space Lecture: "The Color of the Universe." New color imaging techniques for stars, galaxies, and other cosmic objects. Rudolph Schild, Harvard-Smithsonian Center for Astrophysics. Einstein Planetarium, 7:30 p.m.

July 2 Monthly Sky Lecture: "Lunacy at *The Sun*." The *New York Sun*'s 1835 satire about life on the moon. Ellen Sprouls, NASM. Einstein Planetarium, 9:30 a.m.

Handling Charge

The Smithsonian's treasures rate the same kind of safeguarding that the crown jewels enjoy at the Tower of London. We don't—more's the pity—have 16th century Beefeaters armed with halberds. But we do have guards, ubiquitously astroll, or standing, hands behind backs, rocking on heels, eyes narrowed in suspicion. What fate awaits the fool who messes with an aeronautical icon?

Let the punishment fit the crime, I say. The idiot who prods the *Spirit of St. Louis* with a walking stick should be clapped into its cabin after having been kept awake all night, then compelled to take off from a muddy field, badly overloaded, with only a periscope to see through. The culprit should then fly for 33½ hours, still without sleep, land at a strange airport in the dark, and be mobbed by 100,000 howling Parisians. Throw a spitball at the Bell XS-1 and you get stuffed in its cockpit with a freshly broken rib, dropped from a B-29, and fired through the sound barrier.

As for the Wright *Flyer,* I myself live in trepidation that I may one day be forced to fly it. There is hardly a worse punishment for those who have touched that sacred relic out of sheer curiosity. And *mea culpa*: I have touched it.

It happened three years ago, after the *Flyer* had been lowered from the ceiling of the National Air and Space Museum for reconditioning and replacement of its rotted muslin fabric. The work was done in a gallery so people could watch the process and see the bones of the old airplane. Curators reminded shocked purists that the *Flyer* had been repaired many times before the Smithsonian received it in 1948, and little remained of the raiment it wore in 1903. One fragment went to the moon with Apollo 11.

Four months later, when the restoration was finished, I was invited to the *Flyer*'s reinstallment. I showed up at the museum in the evening and found technicians, curators, dignitaries, and members of the Wright family gathered around the airplane, which was now as polished and well dressed as the guests.

The *Flyer* rested on the floor before us. We could walk within inches of it, which I did, hands avoiding contact like a soccer player in a kicking scramble.

"Go ahead. Touch it," said a voice. I turned to see what shape Satan had taken this time and found he occupied the body of Walter Boyne, then the museum's director. So I laid coarse and mortal hands upon aviation's holiest of relics. And I learned a thing or two about mankind's first airplane.

There was a fair amount of anhedral built into the wings—that is, they drooped. It's quite pronounced when you run your hands along the leading edge. It must have made the aircraft so unstable that the pilot had to struggle for control every second aloft.

The brothers devised a wing warping technique to turn the aircraft. A cradle on the lower wing into which the pilot wedged himself was linked to the wingtips by cables. When the pilot shoved his hips to the left, the cables would tug the trailing edge of the left wingtip upward and that of the right wingtip down, resulting in a turn to the left.

I'd read about the cradle and the cables, and had seen them from a distance. Now I shoved the cradle left and right. The wingtips warped astonishingly—nearly a foot. Similarly, the control linked to the small elevator that juts forward of the wings produced an amazing amount of travel. (Yes, I wiggled that, too.)

And so, having sinned, I began to understand the aerodynamics of the fragile, kite-like structure. The elevator was so easily overcontrolled that on its first flight the *Flyer* oscillated wildly for 120 feet before dropping onto the sand.

Compared with a student's first flight in a little Cessna or Piper today, Orville's must have been a horror. Picture him lying on his stomach in a business suit, blinking against sand and wind. As he desperately tries to keep the aircraft's nose on the horizon, he must also hike his hips left and right to keep the wings level. And all the while that 12-horsepower engine blats in his right ear, the chain drives whine around him, and—well, if my punishment is to fit my crime, I've earned 12 seconds of utter hell. But it was worth it.

—Edwards Park

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A Night in the Barrel

There's a little voice in your head nagging at you. *Why are you having so much trouble tonight? You've practiced carrier approaches and tanking a thousand times. If you weren't messing up so badly you'd be in the ready room now, laughing and scratching with the other pilots.*

When you're a navy pilot having trouble getting aboard a carrier, you simply climb up to a tanker and refuel. The entire process usually takes less than five minutes. Then you descend, make another approach, and recover on board. Soon the entire episode is forgotten, just like the walk you take in search of an open shower stall every morning.

Tonight, however, it's not that simple. By everyone's calculations you've got one, maybe two minutes of fuel left. Unless a number of procedures work just right, you and your EA-3 electronics surveillance aircraft are going to go for a swim. There's no particular reason why your number has come up. It just has.

No one who works with the twin-engine A-3 calls it by its Navy designation, the Sky Warrior. It's The Whale. Just the mention of The Whale sends veteran flight deck crews scurrying for cover.

It's the biggest, ugliest, and clumsiest aircraft on board. ("Caution! Handle Carefully" reads a note on its tail. "On Loan From the Smithsonian.") The Whale

Illustrations by John L. Heinly

wallows down the glide slope with a high-pitched whine and lumbers across the ship's stern toward the two-inch-thick arresting wires. After arresting, the 25-ton monstrosity bounces five feet into the air and smashes back down on the deck before coming to a stop. This is called the Whale Dance. Add to the list of eccentricities the fact that it has no ejection seats. And tonight, it's your plane.

Boy, did you get low on that last approach. You got so disoriented you swore you were upside down. Now this tanker's not working right. Please let this be a bad dream.

But it isn't. You've got the yoke in your left hand and can see the KA-6 tanker just a few feet away. If you don't get plugged this time, you and six crewmen are going to have to bail out into the Arabian Sea—at night. The wind is blowing at 30 knots and *if* you survive the bailout and the water entry you've still got to survive the ocean. You may drown—others have. Or Jaws might get you. So what's it going to be: get some gas or take a swim? You align the probe with the lights ringing the tanker's basket and ease toward it again.

When a pilot makes approach after approach without getting aboard it's called "a night in the barrel." Every carrier pilot jokes about it because each has had or will have his night. When it happens, it reduces you to a helpless, frustrated, and scared passenger.

It's a rare night when several pilots have trouble. But once in a while, for no apparent reason, everyone has trouble getting aboard. Then the radar controllers have to give their best instructions, the landing signal officers must use their sweetest calls, and the pilots have to overcome their anxieties and get aboard safely on the next pass. Otherwise they lose everything: their confidence, their self-respect, their navy wings, their airplanes.

With a new load of fuel in the Whale's wings, you slide out from under the tanker and begin your fourth approach of the night. Three miles out and no carrier in sight. Two miles. Finally, at a mile and a half, you see the ship off to your left. The entire scene fits in an area the size of your thumbnail. You fight to get lined up on centerline and glide slope but end up overcontrolling. The landing signal officer waves you off—too low for a safe landing. The same thing happens on the next approach, and you climb back up to refuel.

Two more approaches. On both you miss the arresting wire by inches and bolter—go to full power and take off—and it's back to the tanker again. But now you are no longer alone in the barrel—three other pilots are having trouble getting on board and they have even less fuel than you. They line up ahead of you at the tanker.

The LSO switches to the manually operated visual landing system—MOVLAS—because no one is responding properly to the automated system. The number one airplane traps on its first pass. Then the second airplane, and the third. The rhythm is reestablished—one trap every 60 seconds. The number of aircraft *in extremis* falls from 11 to seven . . . to three . . . to yours.

The tanker pumps enough fuel into the Whale to keep you holding for one of the two tankers just launched, but not enough for another approach. Moonlight diffuses into a cotton haze that surrounds your airplane. Red cockpit lights cascade over your instruments. Visibility is less than two miles, and you waste two minutes—and 10 percent of your gas—trying to find one of the new tankers. You spend another three minutes moving into refueling position—one quarter of your fuel burned just in the attempt to get more. *Please let me get plugged and let this tanker work.* The probe enters the tanker's basket without a hitch. The green lights on the tanker wink on, indicating a good flow of gas. Then, horrified, you watch as a squirt of fuel pushes the basket off your probe. It slaps the side of the Whale with a resounding *whap* and falls into the slipstream. Two more plugs, two more *whap*s. You get plugged again, but now gas streams around the probe instead of into it. Sweat starts trickling down your brow.

The navigator at the tanking control box calmly troubleshoots the problem. "Okay, Zero Zero Four, let's recycle the basket and try it one more time."

The little voice is back, cautioning you about all the things that can go wrong—*it's dark, it's bumpy, and inserting this probe is like trying to thread a needle while riding a roller coaster. At night.*

You stabilize the probe about three feet aft and a little low of the basket. Back pressure on the yoke aligns you precisely. But the bow wave off the nose pushes the basket to the right as you close in. A little right rudder adjusts for this. Two feet, one foot—you're plugged. Is the gas going to stream out and force the basket away again? Seconds expand to hours.

You're proud of how calm your voice sounds on the radio—"Zero Zero Four's plugged and receiving." Everyone monitoring the drama cheers.

But you still have to get aboard. The night carrier approach is the necessary evil that caused all this tanking, and the ship awaits. So does the ocean.

You fly a good approach to three-quarters of a mile. You tell the LSO you can see the optical landing system, then drift a little left. Lowering the right wing corrects the drift, but you're slow in adding power and descend a bit. You overcorrect—now you're too high. *Jeez, you're gonna bolter again.* In the next two seconds you reduce power and push the yoke forward, which establishes a tremendous rate of descent. The hook touches down three feet before the arresting wires, and then the Whale bounces—it looks like you're going to miss all four wires on one bounce. At the last second you pull back on the yoke and the hook drops an inch, just enough to snag the last wire on the fly. The Whale shudders to a halt.

The ship's skipper slumps in his chair and orders the carrier to turn out of the wind. The admiral smiles to himself and begins to sort through a pile of messages. You head for the aviator's wardroom and a greasy hamburger. It was an ugly night, and the approach wasn't pretty. But you're aboard.

—Daniel E. Moore Jr.

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THE BLACK BOX

When airplanes crash, flight recorders often tell why.

by Patrick Cooke

Many people would consider Jim Cash's job unbearably grim. As part of the National Transportation Safety Board's team of accident investigators, Cash listens to tapes from cockpit voice recorders pulled from the wreckage of crashed airplanes.

Cash and his colleagues at the NTSB listen to the language of flight recorders, the "black boxes"

A cockpit voice recorder, like the one recovered from a crash in Virginia (left), told the story of Air Florida flight 90's last moments.

Breton Littlehales

that expose the causes of many airplane accidents. It is a job that demands the skills of both engineer and detective. It also requires a certain amount of emotional detachment: at one point in 1985, black boxes entered the investigators' windowless offices at a rate of several a month.

Cash was only two days on the job when he got his first tape. A United DC-8 cargo airplane had crashed in Detroit in 1983 shortly after takeoff, killing the three crew members aboard. Listening to the tape, Cash realized that the captain had allowed the flight engineer, who was not qualified to fly the airplane, to switch seats with the first officer and handle the takeoff. Because he had made his preflight check in a cursory way, the engineer didn't notice that the airplane's trim tab was still set to keep the nose up for a softer landing. When the flight engineer lifted the improperly trimmed airplane off the ground it rose nose-high, stalled, and crashed.

Five years later Cash still remembers listening to that tape. "The first few get to you," he says. But now, listening to the taped evidence of disaster is just part of a day's work.

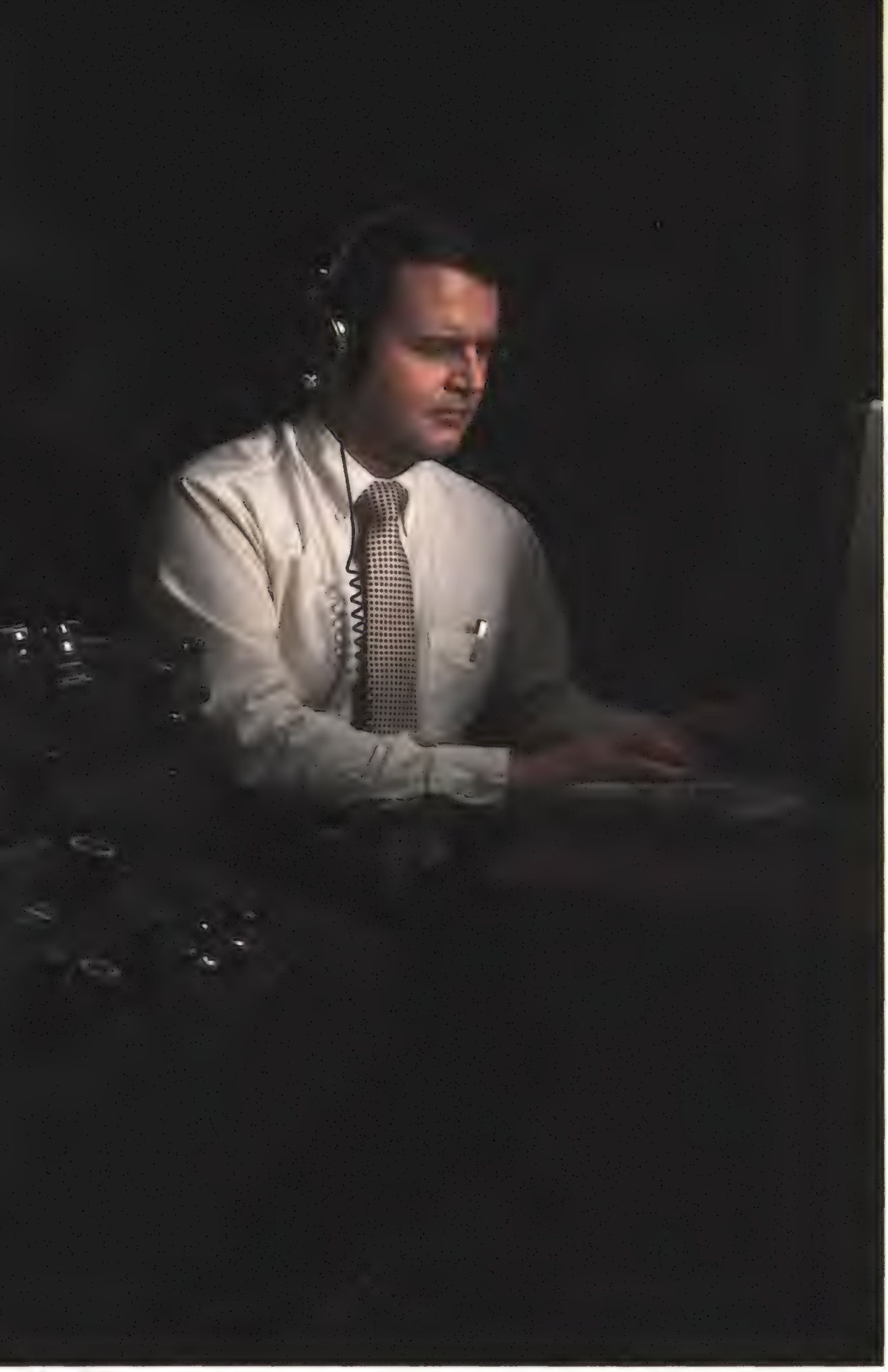
The most distinctive feature of a standard black box is that it is bright orange or sometimes yellow, not black. Officials at the NTSB aren't even certain how the misnomer arose, but in any case the bright color makes the boxes easier to spot in wreckage. The other notable characteristic is that large airliners carry not one black box but two. Cockpit voice recorders pick up conversations and noises inside the cockpit; data recorders record different parameters of the airplane's performance.

The boxes help link together the complicated clues of accident information—control tower radio traffic, weather information, wreckage inspection (see "The Go Team," August/September 1987). Flight recorders alone can't always provide the answers. "It's one thing to be able to read information that comes in," says NTSB engineer Dennis Grossi, "but it's quite another to be able to tell from it what might have happened to a plane." Still, the boxes often send accident investigators in the right direction.

A direction was about all Paul Turner, an investigator who retired from the NTSB last year, had before the black box eventually told him what happened to Air Florida's flight 90 on January 13, 1982. The airplane had crashed into the Potomac River shortly after taking off from Washington's National Airport. A blizzard had passed over Washington that day, and other pilots had seen ice forming on the airplane's wings during the long wait to take off in the storm. The natural assumption was that the ice had led to the crash—but the black box told more.

At some point before takeoff, ice had blocked an outside engine sensor, creat-

At the NTSB offices in Washington, Jim Cash begins his accident investigation by transcribing the tape from a cockpit voice recorder.



Breton Littlehales

ing a false power reading on the gauges in the cockpit. Something's "not right," the copilot said as the airplane rolled down the runway during takeoff. Turner heard the words later on the tape from the voice recorder, but he heard something else as well. He compared the sound frequency of the airplane's engines with normal takeoff frequency and realized the pilot had placed all his faith in the gauges. He simply never gave the ice- and snow-laden airplane enough throttle to climb. By the time the pilot did push the power up, says Turner, it was "too little, too late."

The evidence from the black box made it unlikely that another airplane will be lost for just that reason. But the problem, as it always has been, is that no two crashes are exactly alike.

The black box has changed considerably since the day Charles Lindbergh's *Spirit of St. Louis* carried a primitive version on its transatlantic crossing. (It recorded the altitude and time data needed to verify his flight.) For years afterward, data recorders—sometimes carried on the radio rack or tucked inside the airplane's wheel well—were strictly optional equipment. In 1947 the Civil Aeronautics Board made their use mandatory, but the devices proved so unreliable that the board rescinded the requirement the next year. A decade later the state of the art had developed to the point that the board began requiring flight data recorders on large carriers and commercial airplanes. Cockpit voice recorders became required equipment in 1967.

This year flight recorders on U.S. aircraft are in the middle of a revolution. After years of recommendations by the NTSB (which isn't a rule-making agency), the FAA has proposed new rules making the boxes mandatory on the smaller airplanes of the rapidly expanding commuter fleet. Many recorders already on board larger airliners are due to be replaced by more advanced models. In addition, the FAA is requiring that the boxes collect more kinds of information. "It's a big jump forward," says Grossi. "Of all the major countries, the U.S. had the worst regulations. Now we have the best."

A new flight recorder can cost from $9,000 to $20,000, depending on sophistication, but reliability is improving, and survivability in a crash is all but perfected. Each recording device is enclosed inside a protective casing that rivals an armored truck for security. First it is packed inside tough plastic water-filled bladders, or "shock mounts," which will protect the recorder from impact and shield it for at least 30 minutes from a fire as hot as 21,000 degrees Fahrenheit. A three-eighths-inch-thick stainless steel crash jacket is bolted around the unit, with another layer of stainless steel forming the outer skin. Attached to the outside is an underwater locating beacon that is activated by contact with water and will sound for 30 days with a decent battery. The complete package weighs about 25 pounds and is roughly the size of a small toolbox.

Black boxes are routinely tortured at Fairchild Weston Systems, Inc., one of the handful of manufacturers. In one test a 500-pound weight with a quarter-inch-long protruding pin is dropped on the box from a height of 10 feet. The pin must not damage anything inside the box. Boxes are also baked to thousands of degrees and must survive an impact

of 1,000 Gs for five milliseconds, roughly comparable to a jet at full speed instantly dissipating all its energy into a mountain. Because some crashes consist of multiple impacts, impact forces up to six times that strong have been recorded, but the black box usually survives because it is located as far back in the aircraft as possible—normally the last part of the airplane to hit.

There is only one basic kind of voice recorder used in the United States, but until next year data recorders will come in two forms: scratch type, the first generation of recorders, which airlines began installing after 1958, and the more advanced digital recorder. Grossi sees both kinds come through his NTSB lab in Washington, a bright, noisy room overrun with banks of computer equipment. He is anything but undecided about which he prefers. "The scratch-type data recorder is so sloppy that the information that comes out of it is often just lousy," he says.

Inside a scratch recorder, data is recorded on a roll of light stainless steel or aluminum foil, slightly thinner than common kitchen foil, that travels over a set of rollers at a rate of 1/10 of an inch per minute. Each second, five needles—similar to those on lie detectors—strike the foil, creating scratches indicating changes in altitude, airspeed, vertical acceleration, and heading. The fifth parameter synchronizes timing of the data and voice recorders so that conversations coincide with events when both are played back.

Should an airplane be involved in an incident, investigators send the foil to the NTSB. There, Grossi's technicians unroll it under an optic reader, a kind of microscope, and begin the painstaking task of examining the scratches. Ideally, the trail of marks should give a second-by-second reading of the changes the airplane went through up to the time of the incident.

But it doesn't always work that way. Take the case of a 1982 wind shear accident in New Orleans that downed a 727 carrying a scratch recorder.

"These are blowups of the foil from that crash," says Grossi, holding up a large photograph that looks more like an underwater picture of stones scattered across the ocean floor. "You can see from these tiny scratches where he started to get in trouble." He draws a line through the stones. "Here's where he probably hit the trees. But it's hard to determine from point to point exactly what the progression of marks is. The needles are just too inexact, and if one data point is wrong it throws the whole reading off. So there's an enormous amount of interpretation that goes into trying to piece together what actually happened. Much of it didn't even jibe with the physical evidence that later turned up."

The information from that accident was so unreliable, says Grossi, that in-

David Hathcox

Sometimes a flight data recorder survives an accident in reasonably good shape, making it easier for Dennis Grossi to retrieve its information.

By pairing a data recorder with computer graphics, investigators can simulate the events leading up to an accident.

vestigators did not even bother trying to duplicate the crash on a simulator, a device that allows a flight to be "flown" via computer graphics using black box information.

Much to the NTSB's relief, scratch recorders will become museum pieces by next May, thanks to recent regulations requiring that they be replaced by the more reliable digital recorders. Although they fit into the same containers as the scratch type, the digital recorders are a technological leap ahead of their predecessors. Instead of recording on foil, digital boxes log information on reusable, multi-track half-inch magnetic tape, similar to the tape used for music cassettes except that it can survive up to a year in sea water.

With a digital system, information is plucked from cockpit instrumentation or from sensors placed around the airplane and collected by a small control center called a data acquisition unit. The unit, which is usually not in the black box, converts the data into digitally coded signals, then sends the signals back to be stored on tape.

When a digital tape arrives at the NTSB, a computer decodes the binary data onto yards of printed paper. This numerical readout shows the crucial short-term changes in an airplane's final moments before a mishap.

Breton Littlehales

Aside from the obvious advantage of fewer moving parts, the digital system can record many more parameters than the scratch recorder's five. Most digital boxes record a standard 17 parameters: the five parameters of the scratch recorders, plus radio data, airplane attitude and acceleration, control status, engine thrust, and flap positions. The boxes have the potential to log more than 110 parameters, everything from brake pressure and fuel flows to the position of various switches and the readings of gauges in the cockpit.

Three years after the New Orleans accident, a Lockheed L-1011 crashed in Dallas, also a victim of wind shear. But this time the airplane had a digital recorder. "We learned so much about wind shear from the Dallas crash simply because we could actually document in detail the forces that acted on the plane in the last few seconds," says Grossi. "Probably the greatest advantage of the system is that the more parameters you have, the easier it is to weigh one against the other. If you have a suspect reading you can always go to another place and check it."

No one suggests that the New Orleans crash could have prevented the Dallas tragedy. But investigators do say that accurate information from the New Orleans accident would have at least permitted an additional simulator flight to be made through wind shear conditions, adding to the knowledge about this hazard.

Digital recorders were slow to appear in the U.S. airline fleet. In 1969 the FAA required that airliners carry digital recorders measuring a minimum of 17 parameters, but only airplane models certified after that year were affected. The Boeing 737, for example, was certified in 1966, so 737s were not required to record any more than the basic five parameters using either system.

The reason for limiting the modernization requirements was cost: rewiring a fleet of airplanes and retraining mechanics is costly and time-consuming. "The expense of having a plane off the line long enough to do the refitting is tremendous," says Roy Beiber, senior avionics engineer for USAir. In 1985 that company revamped its fleet with digital boxes that recorded the five required parameters but were capable of recording more with aircraft rewiring. The rewiring will be necessary within two years—both the FAA and the International Civil Aviation Organization have recommended that large passenger aircraft record 32 parameters.

Not everyone feels that increasing the data is essential. "Maybe for some of the newer planes it's a good idea," Beiber says, "but some operators have felt that the NTSB isn't going to learn that much more than they already know about the older planes just because they carry more parameters."

The practice of spending hours standing in front of a tower of sound equipment repeatedly listening to sounds of airplanes breaking up on cockpit voice recorder tapes is a relatively new one. When voice recorders became required equipment in the 1960s, no one was trained to listen for the minutiae on the tapes that might be important. No one, in fact, really knew what he was listening for.

Much of the work of figuring out the system fell to Paul Turner, a former fighter pilot who had survived a year as a POW after his F-86 was shot down over North Korea. A one-time Air Force test pilot with a penchant for gadgets, he had been working as an FAA inspector when the career change came. By the time he retired Turner had heard it all. He listened to laughter and obscenities, and he discreetly ignored intimate details of personal lives. He even heard pilots talking about fatal crashes just moments before their own. But he largely dismisses the notion that his job was gloomy, pointing out that human voices were only part of what he listened for.

Often it is peripheral sounds, not voices, that provide the clues to a mishap. Explosive decompression or fire warnings may be heard on a voice recorder tape, but often that merely exposes a fact instead of offering an explanation. An Air Canada DC-9 that caught fire and was forced to land in Cincinnati in 1983, for example, recorded the fire bells. But it also played back an odd noise that was eventually traced to restroom circuit breakers popping behind the cockpit—a clue to the cause of the fire. Turner once calculated

precisely where lightning had struck an airplane, using only voice recorder tapes and a knowledge of the speed at which sound travels. Jim Cash was able to calculate the takeoff speed of the Continental DC-9 that crashed in Denver last November by listening to the sound of the nose wheel.

But sometimes a tape reveals no obvious details—or worse, raises more questions than it answers. For instance, the recording from a Midwest Express DC-9 that crashed in Milwaukee in 1985 picked up a puzzling noise that may be related to the cause of the accident, but it's never been identified. Laments Turner, "A lot of times you'll hear a pilot say, 'Gee, what's that? I'd better take care of it.' And then they go in. You can listen to it over and over and you'll never figure out what he was looking at."

And then they go in. "You have to separate yourself from the idea of death and look at it as a job," says Turner. "I wouldn't say you ever exactly get used to it, but you can't let it interfere. Yes, there are feelings of sadness and remorse and it gets to you sometimes. You sit there listening, knowing what's going to happen, and you think, *God, don't do it.*"

Black box engineers will tell you that swift advances in their field—and in aviation overall—are saving lives. "The electronics are getting better all the time," says Monty Montgomery, chief of the engineering services division at the NTSB. "Planes are becoming more alike, more controllable, and easier to fly." What keeps the investigators so busy, they say, is that unfixed point where the lines of technology and human action intersect. "If you spend enough time looking at the evidence you'll see that in 90 percent of the cases an incident's cause is due to pilot error," says Grossi. "The airplane may screw up in some way but the pilot

The Charlotte Observer

David Hathcox

NTSB investigations aren't limited to major disasters. The black boxes also provide clues about incidents like this 737 mishap in North Carolina.

Billy Hopper of the NTSB specializes in data from scratch recorders. These older recorders are being replaced by the more advanced digital kind.

makes the situation worse." An unscientific conclusion perhaps, but enough investigators shared it that the NTSB formed a Human Performance Division, a group of psychologists who attempt to explain and improve ways in which decisions are made on the flight deck.

"Ninety percent pilot error sounds like an awfully high number to me," says Andy Yates, a retired 747 captain for United Airlines. Yates is a former chairman of the Airline Pilots Association's Flight Recorder and Voice Recorder Committee, set up in 1967 to counter what pilots saw as a data evaluation system open to capricious interpretation. "We were flying west one night doing a little celestial navigation," Yates recalls. "I saw the constellation Sirius descending and said to the crew, 'Look, the dog's going down.' Immediately I thought, *Now what the hell would the investigators make of a comment like that?*"

Still, he says, the system has come a long way. "A few years ago nobody would even acknowledge there was such a thing as wind shear. 'Can't find anything wrong with the plane,' they said. 'Must be pilot error.' Suddenly the data started showing it."

Black box investigators are proud of their contributions to the unraveling of the wind shear mystery (see "The Might of the Microburst," August/September 1986). The black box has also spurred improvements in airplane design, flight deck operation, runway procedure, and even runways themselves.

The causes of some accidents, however, are still not known, often because the airplanes involved weren't carrying recorders. Most private aircraft don't carry them. Neither do most commuter airplanes.

That situation is changing: last February, following a series of unexplained crashes by commuter aircraft, the FAA took steps to require cockpit voice recorders on commuter airplanes and helicopters seating six or more, as well as 17-parameter flight recorders on airplanes seating between 10 and 19 people and 32-parameter boxes on aircraft seating 20 to 30.

Officials at the NTSB, which has long lobbied for the changes, were pleased, but not everyone shares their satisfaction. John Fredericksen, a spokesman for the Regional Airline Association, doesn't foresee much difficulty fitting the airplanes with voice recorders but believes the extensive rewiring necessary to add data recorders will be "a very expensive endeavor. In many cases," he says, "the airplanes will be taken out of service."

Other developments for the next generation of recorders may include telemetry—recording flight data from the ground. And video recorders may one day be installed in cockpits to help identify suspects in hijacking cases. Yet another possibility is a rugged optical storage system—much like compact discs—that can hold thousands of bits of information. Some speculate that ejectable-on-impact flight recorders would end retrieval problems, such as the failure to recover Korean flight 007's recorders after the airplane was shot down by the Soviets in 1983.

Whatever happens, NTSB investigators don't anticipate going out of business anytime soon. They will continue peeling open flight recorders, looking for the answers only the black boxes can provide.

Balloons Over Venus

For the Vega missions, nations from one world worked together to study the atmosphere of another.

by Greg Freiherr *Paintings by Ron Miller*

Vega 1's probe encountered Venus' atmosphere at midnight—local time—on June 11, 1985. Trailing fire, the Soviet capsule plunged like a cannonball into dense cloud layers just north of the equator. Forty miles above the planet's surface the projectile split into two sections, which continued toward Venus on parachutes. The bottom portion, a one-ton lander, reached the planet's surface an hour later. The other didn't. Thirty-three miles above Venus it shed its parachute, inflated with helium, and rose into the sky, becoming the first lighter-than-air vehicle to visit another planet.

Sixty-four million miles away, in a darkened room at the Jet Propulsion Laboratory in Pasadena, California, voices with French, Russian, and Australian accents crackled over loudspeakers as scientists waited for the radio transmission that would signal the balloon's safe arrival. When the signal's carrier wave finally appeared on the control room screen, the people there erupted in applause.

Fifteen probes, 11 from the Soviet Union and four from the United States, had already been to Venus, but Vega 1 and Vega 2, which arrived four days later, were the first missions involving both countries, part of a project that also included France and six other nations. Launched by Proton boosters from the Soviets' Baykonur Cosmodrome, the spacecraft delivered their planetary probes as they soared by Venus en route to a rendezvous with Halley's Comet. The mission took the name Vega from the Russian words for Venus and Halley—*Venera* and *Galley.*

Weight restrictions almost kept the balloons off the manifest. The original mission plan required the two spacecraft to release their probes from orbit around Venus, but braking to orbit would have required weighty retro rockets. The rockets were eliminated when the mission was revamped to take advantage of Halley's visit, and the balloons were restored.

By using balloons, the Vega probes could provide the first observations of the Venusian winds in action and the cloud layers of an atmosphere very different from Earth's. "The balloons were designed to help answer two major questions about Venus," says Robert Preston, supervisor of the astronomical measurements group and manager of the astrophysics research program at JPL. "Why do the winds blow so fast and why is the lower atmosphere so hot?"

Three hundred years earlier, Dutch astronomer Christiaan Huygens made observations of Venus that led him to wonder if the planet had an atmosphere. This possibility was confirmed in the 18th century, fueling speculation that Venus, so much like Earth in other respects, could harbor life. Later studies from Earth and by planetary probes dimmed that possibility. The clouds above Venus turned out to be composed of poisonous sulfuric acid. And the rest of the atmosphere—almost entirely carbon dioxide with only a trace of water and virtually no oxygen—is a hundred times denser than the blanket of air that surrounds Earth. Flybys and landers sent by the Soviet Union and the United States during the 1960s and '70s established that Venus' atmosphere prevents

The Vegas dropped probes off at Venus (right) before continuing on to Halley's Comet. When they studied the Venusian atmosphere, the probes' balloons searched for lightning, which scientists believe may be present.

heat from escaping, trapping it in an out-of-control greenhouse effect. Earth's atmosphere is hottest at its fringes, but on Venus it is the area near the surface that is hottest, with temperatures up to 900 degrees Fahrenheit—enough to melt lead.

The intense surface heat and crushing pressure of the heavy atmosphere meant short lives for the Vega landers. After less than an hour on the surface, the Venusian environment had destroyed their electronics.

The balloons had it easier. In the clouds 33 miles above the surface the temperature was a relatively balmy 90 degrees. Following parallel courses along the equator—Vega 1 to the north and Vega 2 to the south—the balloons were pushed east to west by winds greater than 150 mph. During the two-day lifespans of their batteries, the balloons journeyed nearly one-third the circumference of the planet and gathered more data about the topsy-turvy atmosphere of Venus than all their predecessors combined.

To survive in an extraordinarily hostile world, the balloons were constructed of 390 square feet of Teflon that was specially woven and varnished. Dangling on tethers 40 feet below them were four-foot-long gondolas that looked more like upward-pointing harpoons than interplanetary weather stations. The points were capped with cone-shaped antennas, and the shafts held electronics—radio transmitters, data processing systems, and temperature and pressure sensors. Anemometers mounted on arms attached to the gondolas' sides measured vertical winds. Light sensors monitored cloud density and searched for lightning on the night side of Venus. The data was radioed in bursts back to the antennas on Earth.

From its conception, the Vega mission had a strong international flavor. It was a French scientist, Jacques Blamont of the Centre National d'Études Spatiales, the French space agency, who in 1967 came up with the idea of exploring Venus by balloon. The Soviets, meanwhile, were looking for ways to study Venus by means other than landers. Joint studies between the French and the Soviets began in the 1970s, and in 1980 Vlatcheslav Linkin of the Soviet Space Research Institute and Roald Sagdeev, the institute's director, formally proposed the balloon experiment. Blamont, who collaborates frequently with JPL scientists, approached the Americans. The timing coincided with a slow-down in U.S. planetary missions, and scientists at JPL and the nearby California Institute of Technology jumped at the chance to get involved.

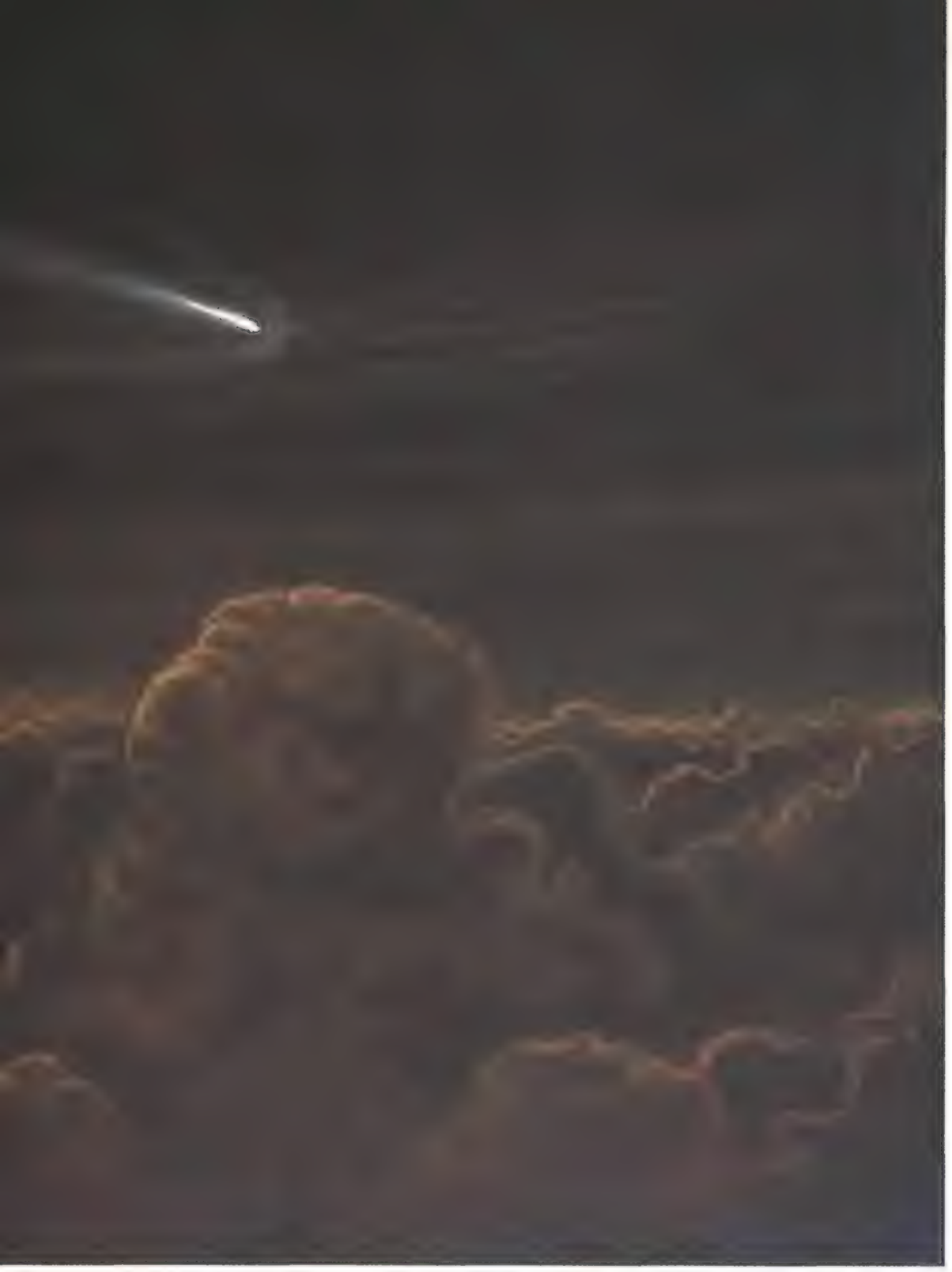
The Vega probes descended from space in long, fiery plunges into Venus' atmosphere. After the probes had slowed, lander and balloon sections parted company for separate missions.

There were, of course, political obstacles. The bilateral agreement for Soviet-U.S. cooperation in space expired in 1982. And on September 1, 1983, Soviet fighters shot down Korean Airlines flight 007, spurring a revival of cold war rhetoric.

"We thought our project was going to be shot down at the same time," says Andrew Ingersoll, a planetary scientist at Cal Tech. The effort continued, but very quietly, with the United States and the Soviet Union officially neither speaking to each other nor working together. The French, who worked with both sides, bridged the gap.

"Trying to avoid the political background was not always easy," says Gerard Laurans, the French engineer in charge of organizing an international network to track the balloons. "We had fantastic luck in this project to have so many clever people on the Soviet and U.S. sides, and very cooperative people trying to avoid all of the political traps that we could meet at any step."

International teamwork was vital to the task of tracking the balloons through the Venusian



atmosphere. Both balloons had onboard radio beacons that functioned like homing devices. The weak signals, ranging between two and four and a half watts, were picked up by a network of 20 antennas on Earth. Knowing the balloons' exact locations, their windspeed measurements, and their reactions to upward and downward bursts of wind, scientists could analyze the motion of the winds in an atmosphere millions of miles away.

The Soviets already had within their own borders six deep-space antennas that could pick up and follow very weak signals from distant spacecraft, but the Earth's rotation would daily take them out of contact with the balloons. "The Soviet Union does not have round-the-world coverage," says Charles Stelzried, a NASA specialist in tracking and data acquisition. "They have a blind spot of about eight hours in every 24."

With help from the French, the Soviets enlisted scientists at 11 radio observatories in Canada, Brazil, Sweden, England, West Germany, South Africa, and the United States. They also added the NASA Deep Space Network, with its three large 64-meter tracking antennas: one near Madrid, Spain, another near Canberra, Australia, and the third at Goldstone, California. "We needed a very large network; we couldn't track the balloons without the U.S. antennas, and also we needed the U.S. knowledge—the data processing," Laurans says.

Balloons for Mars?

Jacques Blamont, the French scientist who conceived the idea of using balloons to explore Venus, has proposed similar Soviet missions to Mars, which could be launched as early as 1994.

The two missions would also include an orbiter and a small automated lander-rover. Each orbiter would release its lander-balloon package for a descent to the Martian surface, then remain in orbit to receive data. After touching down, the lander would release a rig consisting of a helium-filled balloon—to keep the apparatus upright—tethered to a smaller hot-air balloon, open at the bottom to let in carbon dioxide, the major component of the Martian atmosphere. Gondolas would carry cameras and other instruments. Because the Martian atmosphere is much thinner than Earth's, the Mars balloons could be made of a much lighter material than the polyethylene used to make terrestrial scientific balloons, says researcher Christian Tarrieu of the Centre National d'Études Spatiales. Meanwhile, researchers at the Jet Propulsion Laboratory are testing inflatable kites as more maneuverable alternatives to balloons.

During the day, the balloons would float 325 to 1,600 feet above the surface, although they would be able to climb to almost four miles to avoid mountains, according to Vlatcheslav Linkin of Moscow's Space Research Institute. The rigs are expected to travel 60 to 250 miles per day for 10 to 20 days. At night the hot-air balloons would deflate, lowering the instrument-laden gondolas onto the ground for close-up data gathering. Soviet space scientists hope the data will help them in preparing to send a large robotic rover to Mars, a step toward a possible manned mission.

In hopes of stimulating NASA's interest—and, perhaps, participation—in the Soviet mission, the Planetary Society of Pasadena, California, has been working with Blamont and other researchers to study possible balloon missions. One idea that has come out of their studies is the "snake"—a titanium tube with a 2.5-inch-wide hollow core that could be used instead of a gondola for carrying instruments. Made of overlapping conical segments, the flexible snake would slide over crevices and other rough spots on the Martian terrain that might hang up a gondola and its attached balloon.

—Linda Billings

Strangers in a strange land, the landers survived only an hour on the hellish surface.

The big antennas filtered out much of the radio static that accompanied the balloons' transmissions, providing a standard that could be used to find the signals in noisier samples from other, less sensitive radio telescopes around the world. Finding the signal was complicated by inconsistencies in the transmitter broadcast and the jiggling of the balloons in the Venusian winds, which caused the frequency to "wander," JPL's Preston explains.

The political situation has slowed the interpretation of the tracking data. Because five of the six Soviet antennas are used by the military, their locations have been kept secret, despite the scientists' need for precise coordinates to calculate the balloons' locations. "Whenever you're collaborating with your cold war enemy you have to worry that you're divulging some military secrets," Ingersoll says. Early in the project it appeared that the Soviets would reveal the locations. Then they backed off, stating that they would provide the locations with no better than one-kilometer accuracy.

The situation seemed to be deadlocked until the Soviets assigned fictitious locations to the stations and worked out equations that adjusted for the erroneous information. While not a perfect solution, it has worked.

Enough of the data has been processed to enable NASA scientists to recreate a general picture of Venus' atmosphere—at least from the point of view of the balloons. "You can see this balloon did nothing for a long time," Ingersoll says, pointing to a chart of readings sent back during one of the voyages. "It just sat there, not bobbing up and down at all, then it started into some moderate bobbing, and then it just shot way down after being caught in a strong downdraft."

The probes' onboard instruments, especially those designed to measure vertical winds, provided some surprises. On the basis of previous missions to Venus, scientists had thought the planet's cloud cover was split into several relatively stable layers, but the balloons detected unsuspected turbulence in the clouds. Especially surprising were the strength and duration of the vertical winds, with some reaching speeds of 7 mph and others lasting up to four hours.

The winds were powerful enough to endanger the Vega 2 balloon. Toward the end of its mission, as the balloon approached the Aphrodite mountains, it was struck by a sudden downdraft, possibly caused by the mountains 30 miles below. If the downdraft had lasted much longer it could have pushed the balloon to the point where high atmospheric pressure would have wrinkled its rigid skin, perhaps even causing it to collapse. But the balloon recovered and rebounded to its normal altitude—only to have its batteries die a short time later.

The batteries, limited by weight restrictions, had been designed to last until each balloon passed from night into day, when project scientists thought the sun's heat would expand the gas inside the balloons. "We thought the balloons would pop," Preston says. "But they just went right through and kept going," providing more data than scientists had hoped for.

There were other surprises. Temperatures were expected to remain uniform within an individual cloud layer, but the balloons recorded a difference of more than 12 degrees between their positions north and south of the equator, indicating the presence of large eddies in the atmosphere. On Earth, such eddies carry heat from the equator to the poles.

Light sensors aboard the balloons confirmed that the cloud cover was solid, never scattering as it does on Earth. Temperature measurements revealed that updrafts were warmer than downdrafts, which makes sense, since the surface is hotter than the clouds. "But on Venus the atmosphere is so stably stratified that there shouldn't have been any upward transport," Ingersoll says. "That requires some sort of power source pushing the air up and down, and that we simply don't understand."

Venusian lightning is another mystery. "As a matter of fact it is one of the most hotly debated issues about Venus," says Preston. "Is there lightning?" Satellites orbiting Venus had previously reported electrical discharges in the clouds below, which may have been lightning. The balloons came up blank, but that doesn't necessarily mean there isn't any. "We sampled a very small part of time and space," Preston notes.

Once the balloons' batteries had died, their communications with Earth ended. But they must have continued drifting, their radio voices stilled, through the hostile atmosphere of a world so similar to ours in some respects, and so very different in others. They had uncovered much, but Earth's nearest planetary neighbor continues to guard some of it secrets.

Why We Don't Ban the Bomber

Pentagon logic is harder to penetrate than Soviet airspace.

Fred Reed
military columnist,
Universal Press
Syndicate

Is the manned strategic bomber—an airplane intended for carrying nuclear weapons—obsolete?

The answer from the Pentagon is no. The Air Force has just bought 100 B-1B bombers at $272 million a copy, and work proceeds on the Stealth bomber, which has a development price tag of $36.6 billion in 1981 dollars. Despite this overwhelming show of confidence, it is still uncertain that these expenditures are buying the United States more security.

It doesn't matter whether the bombers can reach their targets.

The official justification for the bombers is that they are necessary in case of a strategic war between the United States and the Soviet Union. The reason for doubt is that strategic warfare as a whole has become intellectually intractable. Dozens of exotic technologies untested in combat are embodied in phenomenally complex systems of unpredictable interaction that are intended for use against Soviet systems of largely unknown capacity in a war the nature of which cannot be even approximately predicted. The simple truth emerging from this complicated tangle is that planning nuclear warfare is guesswork.

Consequently, a curious abstraction, an almost theological quality, enters discussions of strategic weapons. Most people in the business recognize it. Time and again I find myself talking to intelligent people who have devoted years to the study of these questions. Listening to some convoluted rationale, I say, "But that doesn't make sense," to which the response is usually, "Yes, but this is what we do for a living." This attitude isn't exactly cynicism. As long as strategic weapons exist, somebody has to pay attention to them. Yet the sense of unreality grows.

Current nuclear policy relies on the familiar triad of strategic bombers, Minuteman ICBMs, and submarine-launched ICBMs. The idea is that even if the Soviets find a way to destroy two legs of the triad (it seems to be envisioned as a tripod), the remaining leg will suffice to wreck the Soviet Union.

But why do we need the bomber leg? Except in strange and contrived scenarios, by the time the bombers reach the Soviet Union, the ICBMs will already have arrived and the bombers will have nothing to do but rearrange the rubble. It doesn't matter whether the bombers can penetrate Soviet radar and reach their targets without being shot down. The threat to the bombers is not Soviet defenses, which might destroy them, but U.S. missiles, which make them irrelevant.

Finding a rationale for building a new strategic bomber has become more difficult than engineering one. Argument number one is that bombers can be called back. This idea appeals to those who think that a war might start as a sort of accident: when Moscow and Washington discover that it is all a misunderstanding, the bombers can be called home. The objection is that the moment the first Soviet missile explodes on U.S. territory, or perhaps before, our submarines will launch. Since missiles can't be called back, what difference does it make that bombers can?

Argument number two is that bombers won't be destroyed on the ground, as presumably missiles in their silos will, because in times of tension they will be kept in the air. But if the Soviets are going to attack at all,

they will do it unexpectedly. Anyway, what difference will it make if they get our bombers? We'd still have missile-bearing submarines, and if the Soviets fail to eliminate just one (and it is far more likely that they would fail to *get* one), as many as 192 nuclear warheads could fall on the Soviet Union. Once again, the existence of missiles makes it very hard to justify the need for bombers.

Argument number three, if a trifle fantastic, at least finds a purpose for the bomber. John Pike of the Federation of American Scientists expresses it well: "It is conceded that the ATB [advanced tactical, or Stealth, bomber, allegedly almost invisible to radar] is intended to penetrate Soviet airspace and seek out mobile ICBMs to draw down their strategic reserve *before* the general nuclear exchange, thus making the Soviets less likely to risk it." Presumably, says Pike, satellite-mounted radar would be used to find these missiles.

The notion that we can dissuade the Soviets from nuclear war by blanketing their territory with invisible bombers that will get their missiles is at least as exotic as the bomber. Pike says, "I doubt that we can succeed in it, and it would be dangerous to try."

By contrast, argument number four, put forward by the prominent military analyst Norman Friedman, is that bombers might be useful *after* the exchange of ICBMs. Most people assume that the war would then be over, but he suggests it might not be, in which case final victory would go to the side with remaining weaponry. A bomber might function as a "dump truck" for repeated bombing of the Soviet Union over the long haul. The argument is not necessarily illogical, but neither is it going to convince the American public that bombers are necessary.

Argument number five is that bombers force the Soviets to divert resources into air defense. Certainly the Soviets spend a lot on air defense. But building bombers as economic rather than military weapons is questionable strategy. These days we might ask whether *we* can afford it.

Argument number six, also suggested by Friedman, is interesting: unlike land-based missiles, bombers are proven. "We have never successfully launched a Minuteman from an operational silo," he points out. "The tests we run at Vandenberg are so artificial that you can't really be sure what they mean. By contrast we know that bombers work. They fly all the time. There is no doubt at all that airplanes, if they aren't shot down, can navigate to a target and drop bombs."

In sum, the bombers will attack before the main war, or after it in a drawn-out grudge match, or bomb a Soviet Union already wrecked by missiles, or spend the Soviets to death. Alternatively, we need bombers because we're not sure our missiles will even work. There is a quality of trying too hard in all of this.

If the military reasons for building bombers are insubstantial, what then are the real ones? The answer is clear to anyone who has covered the military over the years, but it is not an answer that can be proved easily.

First, the crucial point is that when the military situation becomes sufficiently incomprehensible, when the unknowns swamp the knowns, people begin thinking emotionally. Thus Washington is filled with people ardently for or against the MX, the B-1B, and the Strategic Defense Initiative—99 percent of whom do not know what a diode is. Their decisions are based not on reason and knowledge but on their attitudes toward the Soviets. The current conservative administration is doubly distrustful of the Soviets, so to intimidate or attack them it funds two new bombers instead of one.

Then there is the economic incentive. Putting it simply, the productive capacity of a modern economy is such that, to keep ourselves employed, we have to build things that we don't really need. Anxiety over the Russians fueled the race to the moon and has for decades fueled heavy employment in arms manufacture. The aerospace industry would be perfectly happy to abandon military work if it could get equally valuable contracts for, say, a race to Mars. Since we are not currently frightened of a Russian landing on Mars, we build bombers.

The final reason, palpable if not demonstrable, is that for bureaucratic reasons the Air Force can't afford to lose the strategic bombing role. Without bombers, the position of the Air Force in the military order of things would be much less secure. The air interceptor role vanished because the Soviets didn't have an impressive bomber force for us to intercept. Both the Navy and the Marine Corps have their own fighters and use them well. Minuteman missiles could be considered artillery and could easily come under Army control. Loss of the bombers would take the Air Force one step closer to being divided up.

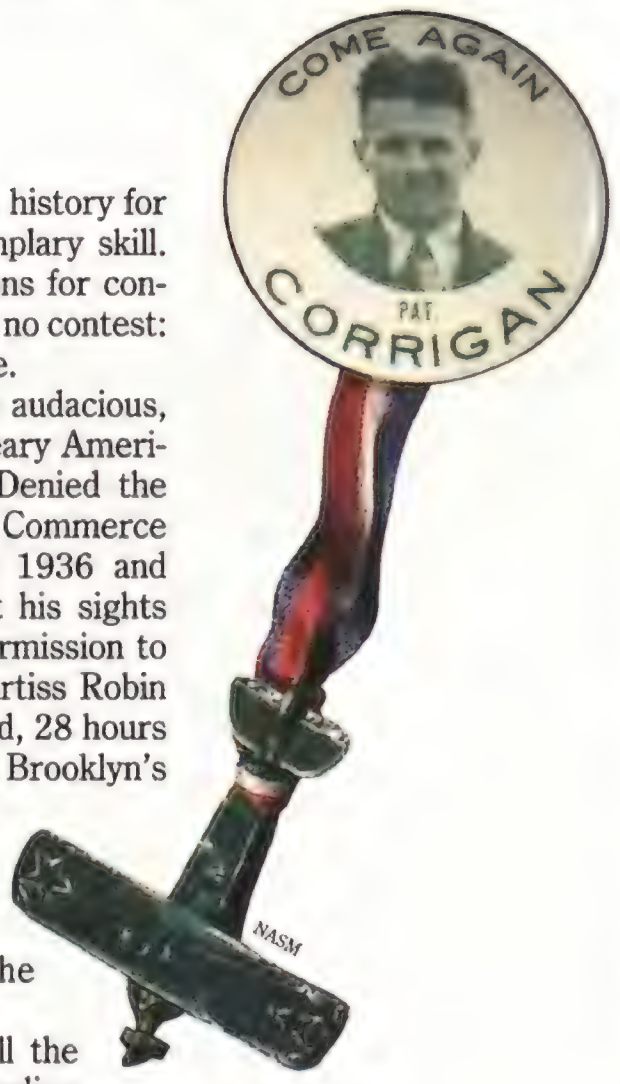
And so, for all reasons except military ones, we continue to build bombers. Yes, they are probably obsolete, but they will be with us for a long time.

The Air Force can't afford to lose the strategic bombing role.

Wrong Way Corrigan Revisited

by Phil Cohan

Fifty years after his famous flight, the right way for Wrong Way is still *his* way.



"My Mistake" and "Come Again" (above) were contenders for the catchiest nickname, but "Wrong Way" stuck.

Corrigan caught America's fancy in a big way. His triumphal parade up Broadway rivaled Lindbergh's.

Many fliers can claim a place in history for outstanding bravery or exemplary skill. But when it comes to citations for conspicuous airborne confusion, there's no contest: Wrong Way Corrigan takes the prize.

Douglas Groce Corrigan was the audacious, witty pilot who gave Depression-weary Americans a reason to laugh in 1938. Denied the approval of the U.S. Bureau of Air Commerce to attempt transatlantic flights in 1936 and 1937, Corrigan had apparently set his sights closer to home and was granted permission to fly his ramshackle nine-year-old Curtiss Robin from New York to California. Instead, 28 hours and 13 minutes after taking off from Brooklyn's Floyd Bennett Field, he landed near Dublin, Ireland, 3,150 miles away. When airport officials informed him where he was, he replied disarmingly, "I must have flown the wrong way."

Many people believe he knew all the time that his little airplane was traveling east rather than west. But nobody's sure. Wrong Way, for his part, said it just goes to show "what a bum navigator a guy can be."

Corrigan's error set off an epidemic of Irishness in all 48 states as America took Wrong Way Corrigan to its heart. More than a million New Yorkers turned out to see him ride up Broadway in his brown leather flight jacket and kelly-green tie. He matched wits with Fiorello La Guardia and drew the bigger laugh with a reference to the New York mayor's political ambitions. There was serious debate as to whether Wrong Way was more popular than Charles Lindbergh had been 11 years earlier. Some New York City officials claimed that Corrigan drew 200 tons more confetti than Lindy did. But of course you have to allow for the Hibernian hyperbole of New York's Irish-American officials of the day.

The crowds loved Corrigan. At every stop on his 44-state tour he delivered clever speeches and one-liners. "I left in a fog and came back in a fog," he told his audiences. Injured by the throng that pressed around him during one of the parades, he commented that America had seen him "from practically every angle . . . but I guess I'll pass up publishing the X-ray." Corrigan ate numerous lunches and dinners that began with dessert and ended with corned beef and cabbage. And almost every city presented him with a special gift: a wrong-way compass or a wristwatch that ran backwards.

When Wrong Way stopped at Galveston, Texas, the city mounted a plaque on the Gill Building, where he had lived as an infant 31 years earlier. And the mayor ceremonially renamed the city's airport Corrigan Field.

Today, Wrong Way Corrigan has been largely forgotten. Over the years the Gill Building fell into disrepair and the plaque disappeared. In time, the airfield's name reverted back to Galveston Municipal Airport and finally became Scholes Airfield, after the man who'd managed it over the prior quarter-century.

Now 81, Corrigan himself has pursued obscurity in recent years, choosing largely to ignore the stream of reporters who persist in asking if the flight was really a mistake. And more often than not, the door of his green stucco home in Santa Ana, California, goes unanswered. "He's in there, definitely," neighbors say. "But he won't answer the door."

When Corrigan did consent to an interview in 1986, it was on his terms—and on his red cement front doorstep. The Corrigan who

Arnold Collection, NASM

Rudy Arnold, Floyd Bennett Field's official photographer, captured Corrigan signing a preflight release—for a jaunt to the West Coast (above).

AP/Wide World Photos

As soon as he reached the other side of the Atlantic Corrigan was a celebrity, and an Irish airport official greeted him like one (right).

Corrigan claimed he owed his fame largely to misreading the compass on the floor of his Robin.

AP/Wide World Photos

stepped out to greet me was a wiry little guy, slight even when compared with his five-foot-five, 120-pound frame of yesteryear. Traces of his old wit and blarney were still evident. And his eyes still flashed brightly, especially when something roused his ire. "Got no use for writers," he said. "They *never* get it right." He said that as we were shaking hands.

Then he asked, "Didja read the book?" He meant his autobiography, *That's My Story.* "Yes," I said. "Brought it with me, in fact." A smile flickered across his face. "Want me to autograph it?" I stammered that I had left it in my motel room. "Plenty of time," he replied. "Bring it by later and I'll sign it for you."

Wrong Way perched on the edge of the step and started to talk. He never seemed to need to stop for breath. And he effortlessly managed to recall names, places, and airplanes from many years ago. I kept trying to interject questions. But Douglas Corrigan's a man who likes to do things his way.

With a flash of his famous grin, he recalled his attempt in 1936, two years before his transatlantic journey, to win approval for a flight to Ireland. The inspector at New York's Roosevelt Field had stared, unbelieving, at his dilapidated single-engine airplane. Then he noted that Corrigan's flight plan called for takeoff from the Canadian province of Newfoundland. Smiling with relief, the inspector said that that locale was outside his jurisdiction.

So Corrigan flew to Hoover Field outside Washington, D.C., and went to the chief inspector's office. Examining the thick file on Corrigan and his rejected flight proposals, the official read a description of the beat-up 1929 Curtiss Robin. As Corrigan tells it, the inspector scowled, pointing to the door. "Don't bother us anymore," he said. "Go away. Get lost!"

Corrigan smiled broadly at the memory. "Two years later," he said, "I *got* lost."

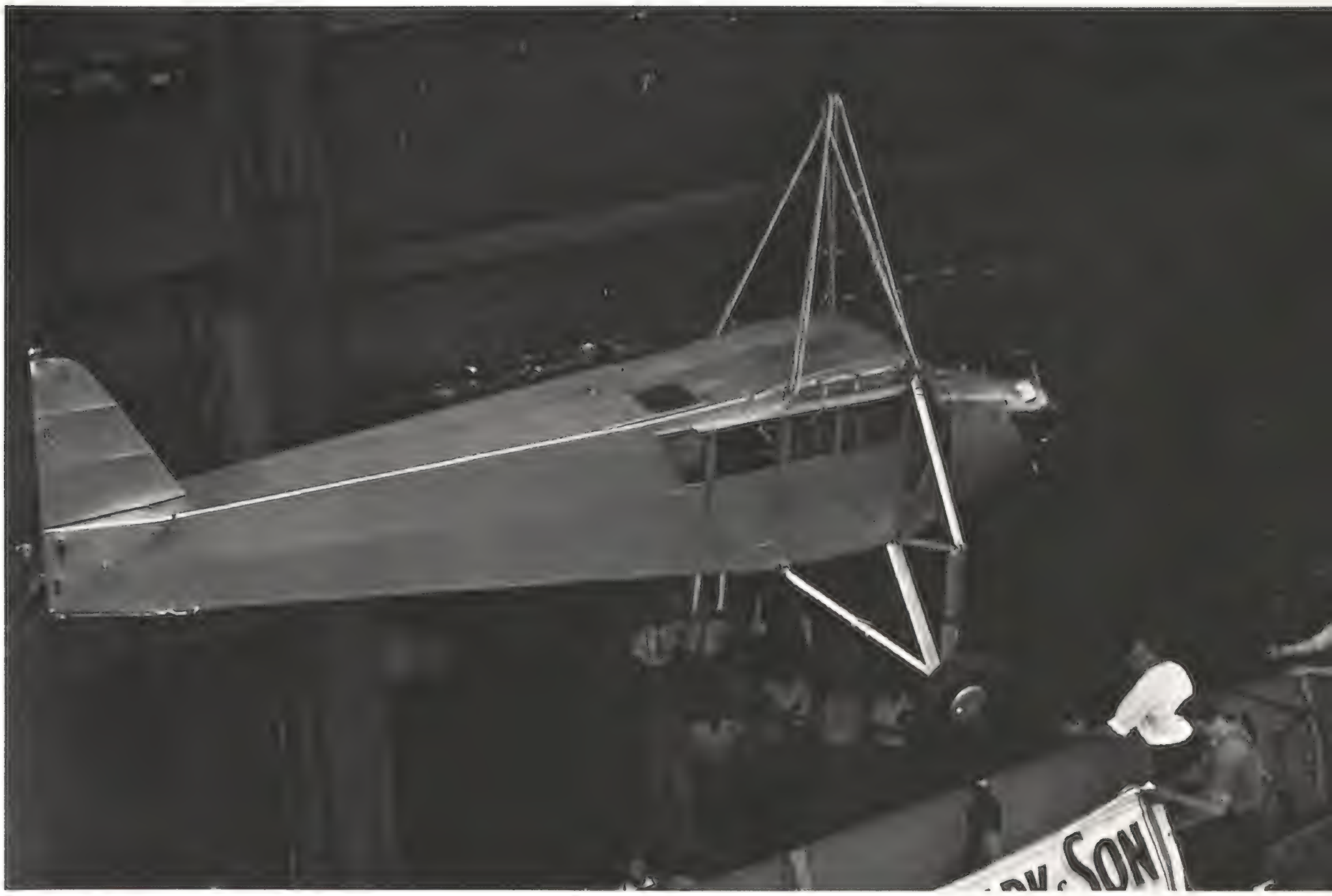
In 1938, any nonstop transcontinental flight was still deemed newsworthy. Corrigan's 27-hour nonstop flight from Long Beach, California, to New York's Long Island normally would have drawn lots of media attention, but when Corrigan landed at Roosevelt Field on the night of Saturday, July 9, all eyes were on Howard Hughes, who was preparing to take off from nearby Floyd Bennett Field the next morning on a record-breaking round-the-world flight (see "The Rise and Fall of Floyd Bennett Field," June/July 1987).

In a way, Corrigan welcomed the distraction. Not long before, inspectors had refused to renew the license for his airplane. He'd modified the Robin somewhat since then, but he still had to badger officials into issuing a license; the Class X license they finally granted put the airplane in the experimental category. So maybe the less attention he and his unorthodox-looking craft drew, the better.

Admittedly, the Robin was a patchwork. Corrigan had replaced its 90-horsepower OX-5 engine with a 165-horsepower Wright J6-5. The nine-year-old radial enabled a speed of just over 100 mph, but it had already run for more than 120,000 miles. The airplane bulged with add-on gas tanks Corrigan had installed in front of the pilot's seat. When one tank sprang a leak, Corrigan had sealed it with several layers of shellac.

The Robin had no radio, no instrument flying equipment, and no de-icer. Nor was there a gas gauge for the added tanks, but the aviator found an easy answer for that. When the sputtering of the engine indicated that a tank was empty, he stuck a wad of well-chewed gum on the fuselage above the cabin's window. That way, he knew how many tanks of gas were left.

Like its pilot, the rickety Robin made the return trip to New York by ship. Corrigan still owns the airplane.



UPI/Bettmann Newsphoto

Around midnight on Sunday, July 17, Corrigan received permission from the airport field manager to take off on the return flight to the West Coast. Four hours later, he and several of the airport staff rolled the Robin out of the hangar. It was still dark. The flier cranked up his engine and checked it over by flashlight. Then he walked over to the manager. "Which way shall I take off?" he asked. The official thought a minute, frowning through the darkness at the Robin. "Any direction you want," he answered, "except don't head towards the buildings on the west side of the field."

Corrigan used 3,000 feet of the 4,200-foot runway to get the overburdened airplane aloft. He was only 50 feet off the ground as the Robin passed over the airport's eastern boundary, but eventually he coaxed the craft to 500 feet. Heavy fog lurked below.

Then, Corrigan's story goes, as he banked to turn westward he noticed that the pointer in the magnetic compass on his instrument panel veered crazily with every movement of the aircraft. When he tapped the glass globe with his finger, he suddenly realized that all its fluid had leaked out.

There was a second compass on the floor, an eight-dollar junkshop relic he says he'd already set for a westerly course. So he turned the airplane until the compass' pointer swung parallel to its pre-set directional lines. Heavy mist shrouded the ground and drove him up above the clouds.

Corrigan flew on. After many hours aloft, his feet began to feel uncomfortably cold. The shellacked seam on the leaking gas tank had given way and his shoes were being quick-cooled as the gasoline on them evaporated.

He was flying at 6,000 feet when darkness fell again. His feet were growing numb; he knew the leak was getting worse. Corrigan trained the beam of his flashlight under the floorboards and saw a pool of gasoline covering the bottom of the cockpit. To prevent it from leaking onto the hot exhaust pipe on the left, he banked to the right and reached for a screwdriver. Lifting the floorboard, he plunged the screwdriver

UPI/Bettmann Newsphoto

The darling of the ocean liner SS Manhattan, *Corrigan handled his sudden celebrity as if born to it.*

Still wearing his battered flight jacket, Corrigan traded quips with New York mayor Fiorello La Guardia.

AP/Wide World Photos

through the liquid and pierced the Robin's fabric skin. The flier heaved a sigh of relief as he saw the gas disappear through the punctured cloth.

Soon after dawn broke, rain began to hammer at the Robin. The air turned colder and the pilot began to worry about ice forming on the wings. He gradually descended to 3,500 feet. Then he saw the water below. He says he thought for a moment that perhaps he'd reached the Pacific. But he'd only been flying about 26 hours. That just wasn't long enough.

Then Corrigan spotted a fishing boat, a small vessel he knew couldn't be far from shore. Shortly thereafter, he saw the green hills. After about a half-hour flying down the strange coast, he saw a large city and, to its right, an airfield. When he saw the name "Baldonnel" in white letters in the middle of the grass, he knew he'd reached Dublin.

Irish officials laughed at his "mistake" and the world joined in. Professing to be "very embarrassed" about the whole thing, Corrigan returned to the United States on the SS *Manhattan.* Aboard the liner, he received a cable from the Department of Air Commerce suspending his flying license for five days; the suspension would lapse on the very day the *Manhattan* docked at New York harbor. Nobody wanted to be known for punishing a popular hero.

In the years since his adventure, Wrong Way Corrigan has held to his story that the flight was the result of a simple error. "It could have happened to any pilot," he says. Not so, most aviation historians say: for a pilot with as much experience and skill as Corrigan had, such a monumental mistake would be extremely unlikely.

And in fact, several times Corrigan himself has punched holes in the story. In a serialized version of his life story in *Liberty* magazine, he recalled the crowd's laughter in San Antonio when he spoke in front of the Alamo. "And I laughed at the people," he wrote, "because I thought they were believing the story I had just told them." In Los Angeles he told guests at a luncheon in his honor: "That was the worst navigation error I ever hoped to make. And I *hoped* to make it, too." And at a dinner talk in San Diego, Corrigan reportedly fessed up to making the flight on purpose, saying that "there are so many aeronautical experts here tonight, it would be foolish to try to fool them."

Mistake or not, Corrigan's was only the 11th solo Atlantic crossing. Yet he still tries to play the whole thing down, insisting that his main source of pride is the 60 days of 1927 when, as a welder for Ryan Airlines in San Diego, he helped build Lindbergh's *Spirit of St. Louis.* "Charles Lindbergh was not

Courtesy Ed Morrow Collection

Courtesy Ed Morrow Collection

Liberty *magazine serialized Corrigan's official life story, but for months his saga—and his famous smile—were everywhere. He appeared with his brother Harry on the cover of* Popular Aviation, *which argued that the transatlantic flight was no mistake.*

Corrigan played himself in the film version of his story. Critics suggested he stick to flying.

Courtesy Ed Morrow Collection

Photographed in late 1984, Corrigan still showed some of the impishness of his youth. He no longer revels in his fame, however, and prefers to be left alone.

Howard W. Rozelle

only a good pilot but he had the highest character," Corrigan asserted. "You could compare him with Lincoln." Then he shook his head. "No," Wrong Way decided, "he was even better than Lincoln; Lincoln was just a politician."

It's plain that Corrigan felt a kinship with Lindbergh and longed to follow in his footsteps. Both were straitlaced—private and somewhat ascetic. Neither man smoked or drank.

But unlike Lindbergh, Corrigan had had a hard childhood. His father, Clyde, deserted the family when the boy was nine. After that, Evelyn Corrigan changed her older son's name from Clyde Jr. to Douglas. When Doug was 13 his mother fell ill with cancer. She died two years later, leaving the boy to fend for his younger brother and sister. He held a succession of odd jobs—soda bottling, trucking, carpentry, and construction—and never really found a niche for himself.

Corrigan caught the flying bug when he was 18. He soloed in March of 1926, then became an airplane mechanic and took most of his pay in airplane rentals and gasoline. He barnstormed across the country, landing in open fields and selling rides to anyone who'd pay. By living frugally, Corrigan scraped together $240 by 1931 and bought an old Hisso-powered Eaglerock. He crashed the airplane in 1933 during a heavy storm. Three months later he bought the decrepit Curtiss Robin for $325.

When Corrigan's Robin took a turn for the east five years later, his fortunes took a turn for the better. A starring role in *The Flying Irishman,* an RKO Radio Pictures film about his life, earned him about $60,000. He got another $10,000 for his autobiography and some magazine articles. And he had his share of income from product endorsements: Mobil paid him $1,500 for publicizing his use of its oil; Sunshine Biscuits furnished another $500 for mentioning that he'd eaten its fig bars on the flight. And, Corrigan claimed with amusement, Wright Aeronautical gave him a gold watch for *not* publicizing that "a 10-year-old engine can run as well as a new one."

On the first anniversary of his flight, Corrigan married Elizabeth Marvin, a childhood friend. A spotty succession of jobs followed. During World War II he joined the U.S. Army Ferry Command as a civilian pilot. When the ferry command released all its nonmilitary fliers, he became a test pilot for Douglas Aircraft. In 1946 Corrigan ran unsuccessfully for the U.S. Senate in California on the Prohibitionist ticket; he was billed as the "plane" man's candidate. He later flew for a local airline and sold aircraft for Northrop and Douglas.

Wanting to settle down, Corrigan and his wife bought a 1,600-tree orange grove in Santa Ana in 1950, where they settled into a happy and quiet existence. Elizabeth's death in 1966 devastated Corrigan, and he began to spend more time by himself.

The hard times of his childhood seemed to be returning. Unable to keep up with his tax payments, he sold the property in 1969, keeping only his house and an adjoining lot. In 1972 22-year-old Roy Corrigan, the youngest of his three sons, died when his small airplane crashed in a canyon on Catalina Island.

Ordinarily, words come easily to Corrigan, who talks the way he flew: nonstop. He had been holding forth for almost three hours now. But his words came haltingly when he spoke of Roy's death. He was clearly happier dealing with the events of 50 years ago.

He seemed to grow more and more pensive as his story wound down. Finally, he fell silent. As I waited for him to begin talking again, a neighbor down the street slammed a door. Corrigan looked up, startled, and rose quickly to his feet. "I've talked too much," he declared, then turned and vanished into the house, closing the door behind him.

Later, in my motel room, I remembered his offer to sign my copy of the autobiography. I decided to take the book back to him. He'd suggested it, after all.

At the house, all was quiet. I knocked on the door but no one answered. I walked around the stucco house several times, then I knocked again. Nobody stirred. Evidently, Wrong Way Corrigan was back to living life *his* way.

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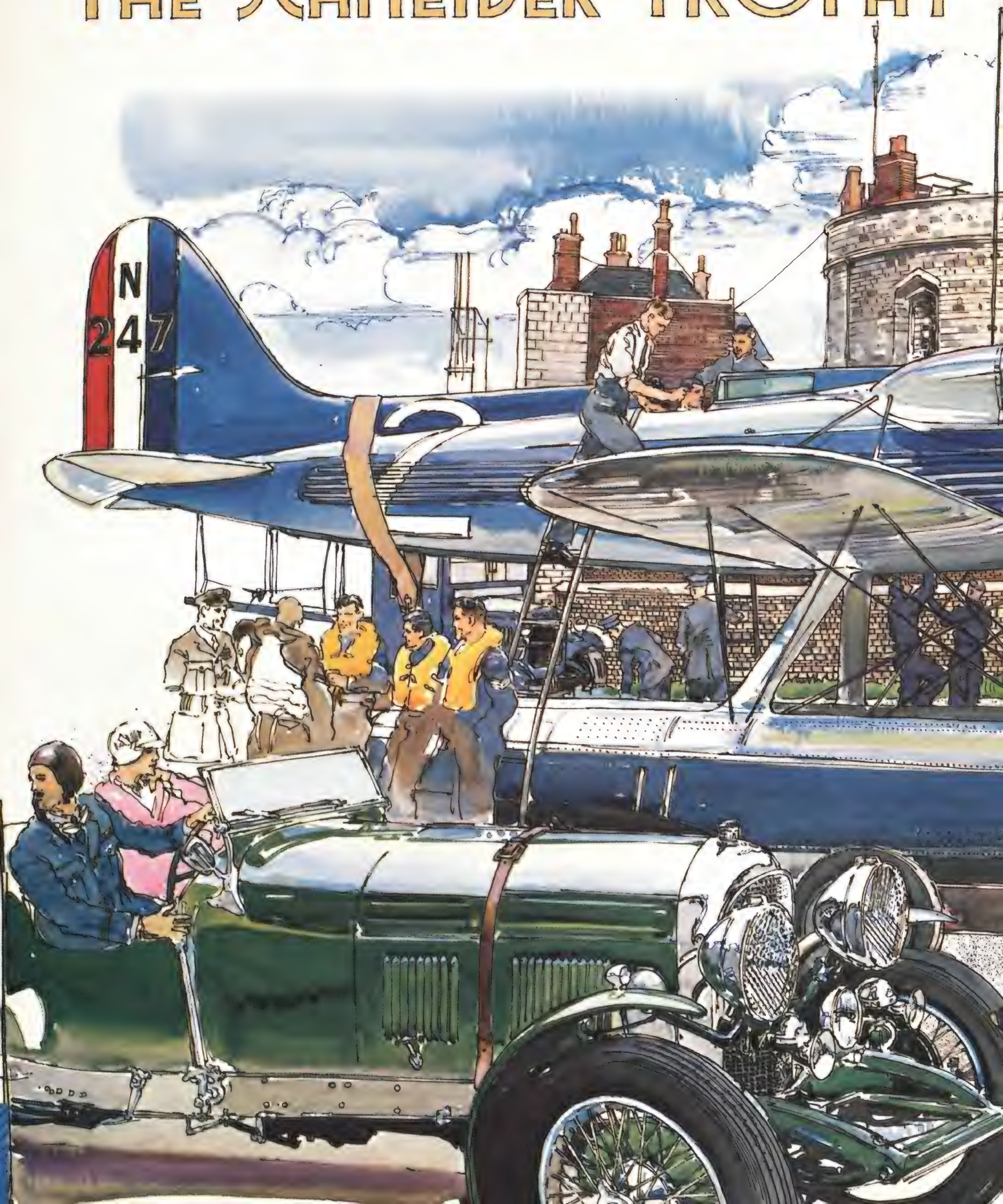
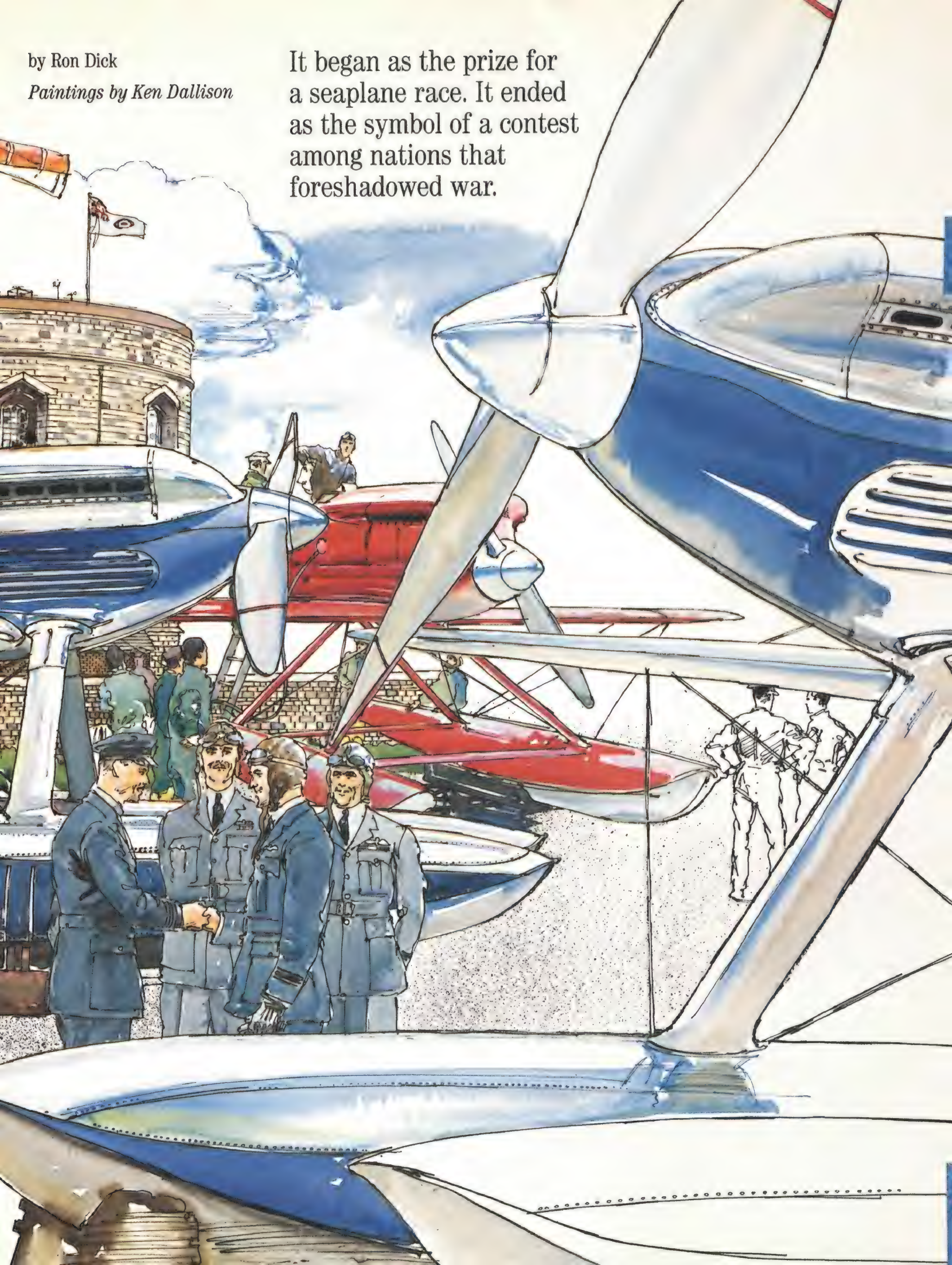


by Ron Dick

Paintings by Ken Dallison

It began as the prize for a seaplane race. It ended as the symbol of a contest among nations that foreshadowed war.



Reginald Mitchell
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Sir Henry Royce
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16 days after the Schneider victory, on 29th Sept 1931 Flt-Lt G.H. Stainforth set a new world speed record of 407 mph.

petrol benzol tetraethyl

FUEL

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Lady Houston at Calshot, 1931
an eccentric widow of a shipping millionaire.

Ramsay MacDonald, the British Prime Minister, with Flt. Lt. G.H. Stainforth.

Ken Dallison 88.

On September 13, 1931, an aviation epoch came to an end. It was one of those rare days of English autumnal clarity, and the weather created a perfect setting for the vast crowds gathered on the beaches and cliffs of southern England to witness the last race for the Schneider Trophy. And because of a series of disasters that had befallen the competing Italian team, the onlookers knew the winner would be British. According to the rules, any competitor who managed to win the trophy three times in a row gained permanent possession of it. The Royal Air Force team, which had won the two preceding races, prepared to do just that for Britain.

It was a pity that the French and Americans had long since dropped out, but the important thing was that this was a chance to wave the Union Jack and cheer a British triumph. It was a triumph that had been a long time in the making, one that might well have been celebrated by another nation, and one whose true measure would not be taken until the dark days of World War II.

The Schneider Trophy produced results its founder never would have predicted. Jacques Schneider launched the competition to foster development of commercial seaplanes, but he lived to see his original conception changed dramatically by the inexorable forces of international rivalry. The son of a wealthy French armaments manufacturer, Schneider loved high-speed boating and became a notable driver of hydroplanes. After meeting Wilbur Wright in 1908 he became passionately interested in aviation, but a crippling hydroplane crash two years later kept him from flying.

Given such experience, it is not surprising that Schneider thought to use his wealth to leave his mark on the aeronautical world, and do so in a way that combined his two greatest loves. He believed that in the future, nations would be linked by hybrid vehicles that had attributes of both hydroplanes and flying machines. His vision turned out to influence aircraft design for many years to come.

At the banquet following the fourth Gordon Bennett Aviation Cup race for landplanes at Chicago in 1912, he announced *La Coupe d'Aviation Maritime Jacques Schneider.* It would be an annual competition to encourage the development of practical aircraft capable of operating reliably from the open sea with a good payload and a reasonable range. Schneider had no desire to spawn a family of freakish racing machines.

In light of later events it seems fitting that Schneider chose the Bennett banquet as the occasion for his announcement. The Gordon Bennett competition had been truly international, and by their very nature the races exerted political pressure on national authorities to become involved, sometimes against their better judgment. Simply put, while the Bennett was there, it had to be won. When the French ended the competition in 1920 with their third successive victory, there was an almost official sigh of relief. But as the public's attention turned increasingly to the Schneider, it became inevitable that the race should go to the swift rather than the practical.

The two pre-World War I Schneider Trophy races conformed to the founder's intent: they were fought between aircraft entered by individuals or private companies. Most entries were hastily converted landplanes or were derived from existing designs. The races were suspended during the first world war, and by the time they resumed in 1919, the

Jacques Schneider commissioned the trophy that launched a seaplane competition in 1913 in France.

aircraft industries of the major powers, driven by wartime demands, had attained far higher levels of technological prowess. It did not take long for competitive flying to regain the place it had lost as the motivation for development, but until 1923 it seemed that Schneider's dream would remain intact. The flying boats that dominated his race did indeed encourage the belief that the globe could be spanned.

The technology displayed at the Schneider races trailed the ingenuity of the aircraft industry, however, and there was little real competition. The Italians built the best flying boats, and other nations were not very interested in taking them on, even though by 1921 the winning speed was only 118 mph. Except for a disqualification in 1919 and the introduction of a chubby little British flying boat in 1922, the Italians would have won three in a row and so gained permanent possession of the trophy—a less than memorable victory, had they managed it then. Their failure saved the competition for greater things, and in 1923 the contest underwent an irreversible change.

The competition between the U.S. services in the early 1920s had produced a series of outstanding Curtiss racing biplanes—slim technological wonders produced by government funding, military rivalry, and public acclaim. Of far greater importance was the fact that the Navy team representing the United States' debut at the 1923 Schneider race was composed of experienced, disciplined pilots and backed by a thoroughly prepared support organization. The Curtiss CR-3 floatplanes snagged first and second positions, with the winner, Lieutenant David Rittenhouse, averaging over 177 mph, a demonstration to Europe of the rapid strides U.S. aviation had made since World War I. The victor hosted the next competition, and now the Europeans had to face the prospect of competing on the other side of the Atlantic for the first time.

From then on, both flying boats and private efforts were outclassed. In light of such harsh realities, first the French and then the Italians decided to withdraw from the 1924 race at Baltimore. The British produced a promising contender known as the Gloster II, but only five weeks before the race the little

Maurice Prévost of France, sitting in the Deperdussin. The winner of the 1913 race in Monaco.

Maurice's mother to his right and the designer of the Deperdussin, Louis Béchereau, to his left.

The Deperdussin, winner of the first Schneider Trophy: it was powered by a 160 h.p. 14 cylinder Gnome rotary type engine, average speed 45·75 mph.

biplane porpoised savagely just after touching down, turned over in a wall of spray, and sank. With the last of the 1924 challengers gone, the U.S. Navy team could have flown sedately around the Baltimore course unopposed to claim their second win.

Given the extent of U.S. preparations, which had also involved the loss of an aircraft, the despondent Europeans were astonished when the Americans canceled the race. The Royal Aero Club at once cabled "warmest appreciation of this sporting action." It ended up being much more than that. As things turned out, it could be argued that the magnanimity of the U.S. National Aeronautical Association prolonged the life of an extraordinary competition enough to indirectly influence events in the coming world war.

The British and Italians finally made it to Baltimore in 1925, and there were signs that they had learned lessons from their previous humiliations. U.S. dominance was correctly attributed to meticulous preparation by a professional team, fully supported in every way by its government. Although not yet prepared to go quite so far, the Air Ministry in London took a first step and ordered aircraft from two companies for "technical development." Gloster refined an existing biplane, but at Supermarine a young designer named Reginald J. Mitchell started from scratch.

Mitchell was still only 30 years old and virtually self-taught in aerodynamics, but he had been chief engineer at Supermarine for five years. He showed himself to be full of innovative ideas, as his first venture into floatplane design revealed. His Supermarine S4 was a beautifully proportioned midwing monoplane, and because it was known that wing bracing added considerably to an aircraft's drag, he left the wings unbraced.

Regrettably, the S4 did not reach the starting line. During a trial flight severe wing flutter set in during a turn, and the aircraft crashed into the Chesapeake Bay. Mitchell was watching from the rescue launch at the time and was sure that the pilot, Henri Biard, had been killed. The designer was immensely relieved to see a very vocal helmeted head finally emerge from the water, but with typical Anglo-Saxon restraint he asked only, "Is it warm?"

With the S4 so dramatically removed, the U.S. team had little difficulty achieving its second victory. Lieutenant James Doolittle won for the U.S. Army, roaring home in his Curtiss R3C-2 at over 232 mph. The American public was looking forward to claiming the trophy permanently in 1926.

But the U.S. government was not prepared to support the rapidly escalating costs of any further development work, leaving the Americans with no new aircraft for 1926. Both Britain and Italy believed that because of the increasing complexity of the aircraft involved, the Americans would agree that it was only sensible to change the rules and run the contest every other year. However, with no funds available for further high-speed research, the U.S. authorities wanted to get the Schneider competition over and done with. They insisted that the race be held as planned at Hampton Roads, Virginia.

The British stubbornly refused to believe that this was the last word, but Benito Mussolini saw an opportunity to show the world that nothing was too difficult for a Fascist state. He instructed the Italian aircraft industry to "win the Schneider Trophy at all costs." In the early part of 1926, nobody in the aviation world gave the Italians the remotest chance of success, but *Il Duce*'s exhortations and money were wonderful encouragements to the nation's aviation industry.

With no time available to develop original ideas, Italian designers sensibly set out to improve on the work already done by others. At Fiat they had studied the Curtiss engines and were sure that they could provide a racing engine that would deliver the necessary power. The airframe to be built around Fiat's AS2 engine was entrusted to Mario Castoldi at Macchi. An intuitive aerodynamicist, Castoldi had a flair for absorbing and adapting the best ideas of others. He drew heavily on the lessons of the Curtiss racers and the Supermarine S4 in designing his M39, a firmly braced monoplane that had very clean lines and was obviously promising.

But before they ever left Italy, the Italians lost their captain in an accident. And after their arrival in the States, they were dogged by a series of carburetion and oil-cooling snags that led to an engine failure and two fires.

The U.S. team fared even worse. Its morale was badly shaken by the loss of three aircraft and two pilots in the last weeks before the race, and the limitations of the aging Curtiss biplanes were revealed when the Italian pilot, Mario de Bernardi, got his M39 to perform reliably. Bernardi won handily at over 246 mph, and his telegram to Mussolini said simply: "Your orders to win at all costs have been carried out."

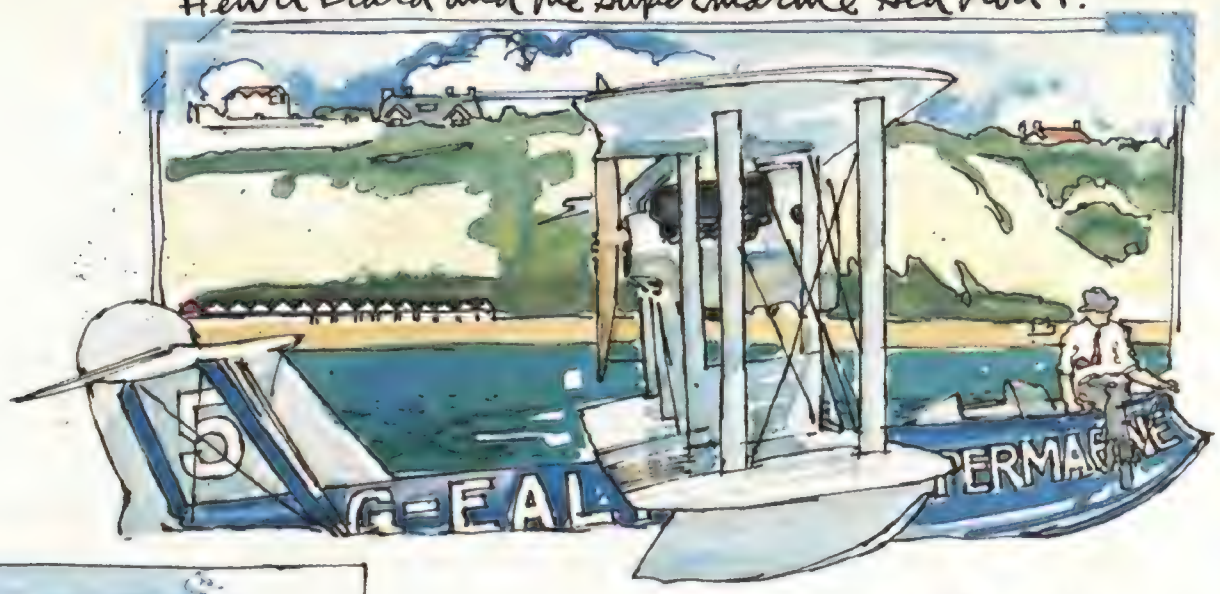
Ironically, the intervention of a Fascist leader ended up providing the British with another chance to get properly organized. The Air Ministry ordered new high-speed aircraft from three companies: Supermarine, Gloster, and Short Brothers. This positive step was followed by another: the chief of the Air Staff, swallowing his misgivings about full Royal Air Force involvement in racing, asked the elite RAF High Speed Flight team to represent Britain. The scene was set for the final act of the Schneider Trophy drama.

The last three races of the competition were held in 1927, 1929, and 1931, a general agreement having finally been reached that at least two years were required between races for proper aircraft development. In the States, many people felt that an attempt should be made to achieve a third victory, but the manufacturers had had quite enough of experimenting and longed for more profitable ventures. Neither the Navy nor the Army was prepared to set aside further funds for racing aircraft, and the United States never again raced for the Schneider Trophy.

The French, who since 1919 had managed to get only one aircraft as far as two laps around the seven-lap course, could not compete in 1927. In 1928 the government ordered two racing seaplanes from the Bernard and Nieuport-Delage companies and formed a racing unit of the Armée de l'Air. New engines were proposed by Hispano-Suiza and Lorraine, but the work that was done came too late for the 1929 race. Though development continued in the hope of competing in 1931, the French continued to lag behind. On September 5, 1931, after crashes destroyed two aircraft and killed one pilot, France finally withdrew.

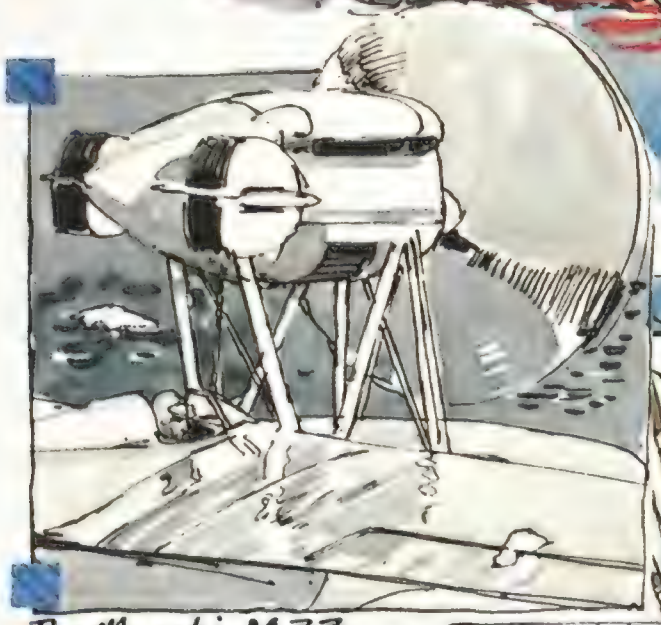
It was left to the Italians and the British to fill the center of the stage during the contest's closing years. The principal

Henri Biard and the Supermarine Sea Lion I.



France entered the Latham in 1923.

Macchi M 39 flown by Major Mario de Bernardi, winner of the 1926 race at Hampton Roads.



The Macchi M 33.

Macchi M7, piloted by Giovanni de Briganti, won in 1921.

Supermarine Sea Lion III

Howard Pixton's Sopwith, winner of 1914 Monaco race.

Lieut Rutledge Irvine piloted the Curtiss CR-3 in 1923.

The Troublesome Gloster VII with the Mauretania in the background

Curtiss R-3C-2 Lieut Doolittle won the 1925 race and also set four world speed records.

Major Mario de Bernardi being chaired after his victory

Designer Mario Castoldi

Flt-Lt John Boothman, shouldered here by his crew after winning the Trophy outright

Italian standard bearer throughout was Macchi. For the 1927 race in Venice, the company drew on the success of the M39 to build the slightly smaller and even cleaner M52, with the goal of reaching 300 mph. The M52 was fast and good-looking but extremely temperamental. To compound the Italians' misfortunes, team member Lieutenant Salvatore Borra crashed into Lake Varese while practicing and died.

The British approached the 1927 race with the first full backing of the government and the Royal Air Force. This meant that money was available to pursue several lines of research and development at once. The end product would be flown and supported by highly trained RAF personnel.

Mitchell had taken to heart the lessons of his ill-fated S4 and had seen the success of Macchi's M39. Accordingly, the S5 wing was fully braced and also lowered to the bottom of the fuselage to increase the pilot's field of view. Fuselage streamlining was improved, and the S5, much smaller than its predecessor, was expected to be up to 70 mph faster.

In many ways the 1927 race was less colorful than those of earlier years. Without private-venture entries, much of the silk-scarf dash seemed lost forever. There was no lack of excitement, however. The clash of two such professional racing teams mounted on purebred chargers was an exhilarating prospect.

The S5s justified their promise and finished first and second, the winner recording an average speed of almost 282 mph. The M52s were not as fast, and all three retired with engine trouble. Once the despondency of defeat was overcome, the Italians made determined preparations for revenge in 1929.

Racers flew the course against the clock. Fastest computed speed took the trophy.

They had a number of weapons from which to choose. The Fiat C29 was an orthodox racing seaplane, but very small, having been built to take advantage of the firm's new lightweight AS5 engine. The spectacular Savoia-Marchetti S65 had its tiny cockpit jammed in between tandem engines driving both tractor and pusher propellers; the tailplane was carried on twin booms. The revolutionary Piaggio PC7, floating directly on its wings in the water, was urged onto its hydrofoils by a boat propeller. A clutch then transferred engine power to the air propeller for takeoff. Unfortunately, none of these aircraft was able to compete for the trophy. The C29 was destroyed in a crash, the PC7 was never able to rise out of the water and gain sufficient speed, and technical problems associated with the S65 proved too great.

In 1929, temporarily disgusted with Fiat's engines, Macchi turned to an Isotta-Fraschini engine for its M67. This new marriage of airframe and engine proved irreconcilably unhappy. The pilots suffered from what they considered dangerous levels of exhaust fumes sucked into the cockpit while they were flying. The Italian team leader, Captain Guiseppe Motta, was killed when he crashed into Lake Garda at high speed, putting the Italians badly behind. The team arrived in England dispirited and sadly lacking in flying practice.

In England, Mitchell had decided that the reliable old Napier Lion engine had been pushed to its limit and a lot more power was needed. The only alternative was Rolls-Royce. Earlier, the government had prodded Rolls-Royce into developing the Kestrel, insisting on a British engine to match the Curtiss D-12. Rolls' managing director was not enthusiastic about aircraft engines, but the government again applied pressure, and the company finally agreed to cooperate. Starting with the Buzzard, a large relative of the Kestrel, Rolls-Royce produced the R engine, capable of turning out a reliable 1,900 horsepower, in only nine months.

Although similar in appearance to the S5, the S6 was noticeably bigger because it had to accommodate the R. It was Mitchell's first all-metal aircraft, and to dissipate the great heat generated by its engine, it was covered with cooling panels. Well designed and meticulously prepared, the S6 inspired confidence among its RAF pilots. Then, at the eleventh hour, an incident occurred that could have handed the trophy to Italy.

On the night before the race, a Rolls-Royce mechanic changing the spark plugs in the leading S6 detected a tiny spot of white metal on one plug. Fuel combustion was heating the face of the piston to the melting point, and a bit of molten metal had migrated to the plug. The supervising engineer confirmed the likelihood of piston failure. The rules forbade an engine change at this late stage but allowed the replacement of parts. The entire cylinder block would have to be removed in some manner, but how? The job would take an army of technicians.

Finally, someone remembered that a party of Rolls-Royce fitters had come to town to see the race. Summoned from their

Gnome Monosoupape air-cooled rotary; it developed 100hp.

Gnome

Curtiss D-12

Macchi-Castoldi MC.72

FIAT A.S.6

Two Fiat A.S.5s bolted together the giant twenty-four-cylinder A.S.6 it was 11ft long.

Rolls-Royce R 2,350hp is what Mitchell needed.

ROLLS-ROYCE R

Supermarine S.6

pre-race celebrations, they rolled up their sleeves and set to work. Shortly after dawn the engine was given a test run. It performed perfectly.

The night's efforts could not have been better spent. Both of Italy's M67s were forced to retire during the race and were replaced with the M52, the fastest of the Italian backups. The RAF's second string was disqualified for missing a pylon, but Flying Officer H.R.D. Waghorn and the repaired engine won the race at over 328 mph, with the M52 finishing second.

Now, with final possession of the Schneider Trophy within its grasp, the British government, as its U.S. counterpart had done, found the cost of competing prohibitive. Withdrawing all support, it left the defense of the trophy to private enterprise. The government of the day was socialistic, so the situation was a bit ironic.

Throughout the following year the government stood firm under the withering attacks of the British press and public. With £100,000 needed to develop suitable aircraft and prepare for the race, it appeared that Britain would join the United States in walking away from the competition. Then, when all seemed lost, a fairy godmother made her entrance.

Dame Fanny Lucy Houston was the eccentric widow of a shipping millionaire, and she had two commodities in abundance: money and a hatred for socialists. When Lady Houston was not lambasting the government in her magazine, the British *Saturday Review,* she was proclaiming her revulsion at its practices by means of a large sign mounted on her yacht, *Liberty.* Early in 1931 she sent a message to the British prime minister that read in part: "To prevent the British Government being spoilsports, Lady Houston will be responsible for all extra expenses necessary beyond what can be found, so that Great Britain can take part in the race." Later, when she made it clear that she would personally guarantee the entire £100,000, the government changed its mind and authorized the RAF to enter the race for the third time.

The Italians, meanwhile, were more determined than ever, and this time their efforts were concentrated behind Macchi alone. Mario Castoldi returned to Fiat's fold for his engine, and Fiat's response was dramatic. The company upgraded two AS5 engines and bolted them back to back to form a single power unit 11 feet long. This monster was supercharged to give a phenomenal 3,000 horsepower, and to house it Castoldi built the MC72, perhaps the ultimate in racing floatplanes.

Naturally, Mitchell wanted more power for the latest version of his aircraft, the S6B. Rolls-Royce obliged by boosting the R engine to 2,300 horsepower. The resulting combination was both fast and reliable.

In Italy, yet another tragedy was being played out. The MC72 was clearly very fast and its mighty new AS6 engine ran beautifully on the ground, but in the air it suffered from tremendous backfiring at speed. The Italian team persisted in flying it to pin down the trouble, and two aircraft and two pilots were lost in violent accidents. After pleading in vain for a postponement of the race until 1932, the Italian authorities made the sad decision not to compete in 1931.

Final confirmation of the French and Italian withdrawals came only one week before race day, and the British found themselves in the same predicament that the Americans had faced back in 1926. It was certain that the British government would not be coerced into competing again, particularly since Lady Houston's magic wand was unlikely to wave more than once. It was now or never.

The plan was to fly both S6Bs. The first, piloted by Flight Lieutenant John Boothman, would fly the required seven laps of the Schneider Trophy course. Assuming success, the second S6B, flown by Flight Lieutenant George Stainforth, would attempt to break the world speed record over a straight three-kilometer course.

Shortly after 1 p.m. the R engine roared to life and Boothman moved off into open water. A few minutes later the slim silver and blue S6B dove for the starting line. Seven laps later, the song of the Rolls-Royce engine as strident as ever in his ears, Boothman flashed across the finish line to record a race average of just over 340 mph. The British had won the Schneider Trophy.

To cap an almost perfect day and send everyone home happy, Stainforth hit 379 mph, a world record for any type of aircraft. Two weeks later, using a sprint version of the R engine generating more than 2,600 horsepower, he raised the record to 407.5 mph, thereby becoming the first aviator to exceed 400 mph.

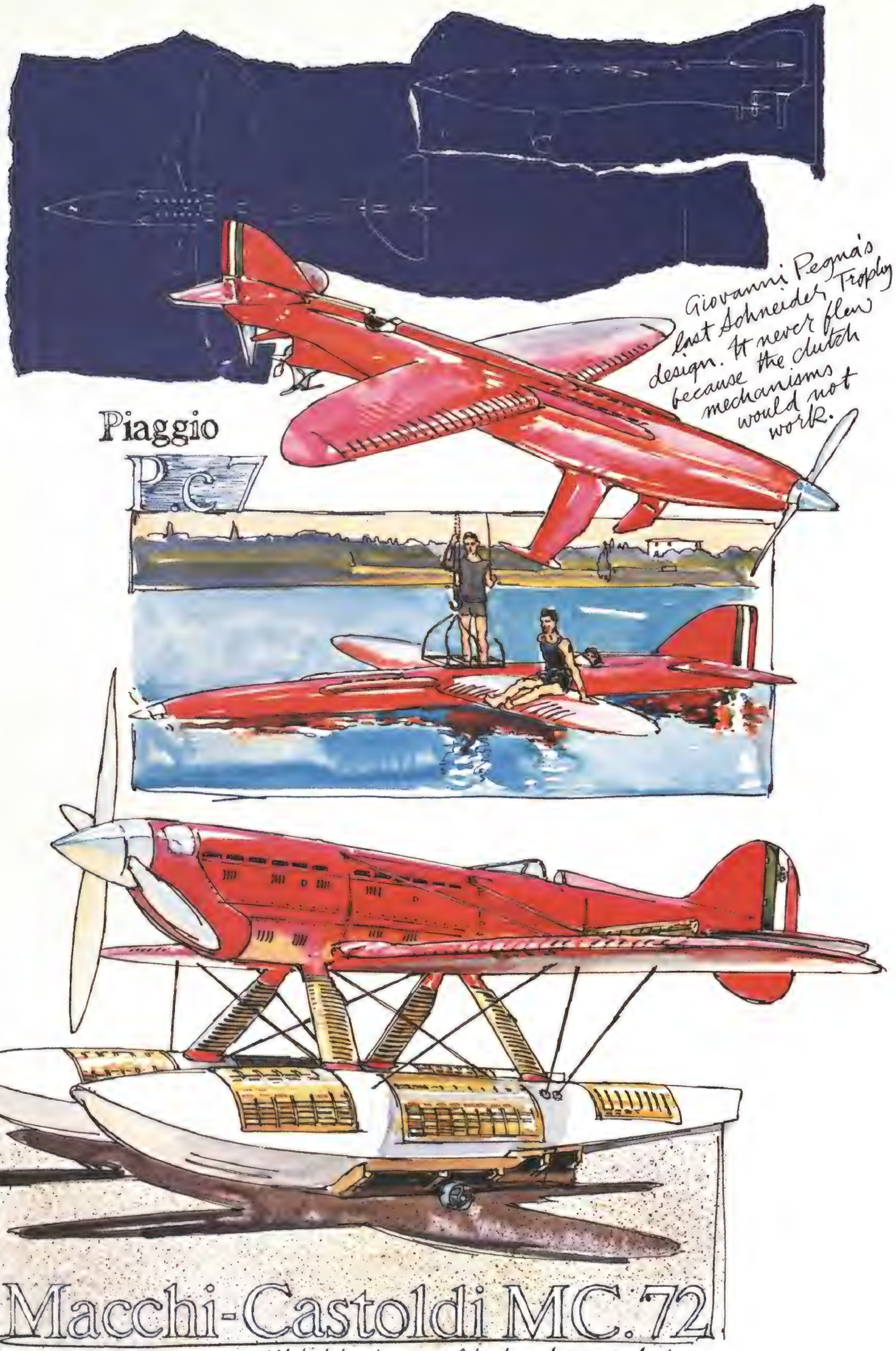
Persistent even in defeat, the Italians invited British fuel wizard Rod Banks to advise them on carburetion in the AS6. He concocted a fuel mixture that the engine seemed to enjoy, and by 1934 the MC72 raised the world speed record to 440.681 mph, a figure that, for floatplanes, stands to this day.

With the achievements of the S6B and the MC72, the era of great international air racing came to an end. Jacques Schneider's dream of world-shrinking "hydro-aeroplanes" had been realized in the very racing freaks he had wished to avoid promoting, but even he would have been impressed by the progress made in less than two decades. The best of the earliest racers, the Sopwith Tabloid, was flat out at 92 mph. Less than 20 years later the MC72 proved almost five times as fast. The standard Gnome Monosoupape rotary of 1913 weighed 250 pounds and produced 100 horsepower. Rolls-Royce's R engine weighed more than six times as much but was over 26 times as powerful.

Of the four principal nations involved, France got the least out of the competition. The United States changed the character of the race and administered the shock that stimulated the rapid advances made in both Britain and Italy. But after the U.S. withdrawal in 1926, it began to lag behind Europe in development of engines and airframes for long-range, high-speed fighters.

The Italians gave the most in their determination to win the "*Coppa* Schneider." They submitted entries for more races than anyone else, their designs were frequently the most imaginative, and they lost the most pilots—seven in all between 1922 and 1931. Ironically, the marvelous Fiat engines were forgotten, and in 1941 Castoldi had to turn to Germany to find a liquid-cooled engine for his fighters.

The British made the most of their experience. Mitchell's work on the low-wing monoplane form, begun on the S5s and S6s, eventually led to the superb Spitfire. The Rolls-Royce R engine fathered the illustrious Merlin, which powered not only the Spitfire but also the Hurricane, Lancaster, Mosquito, and,



The Macchi MC.72 still holds the world speed record for propeller floatplanes.

as persuasive evidence of the effect of the U.S. withdrawal, the P-51 Mustang.

The effect of the competition, though, extended beyond the creation of just one engine. During this period, supercharging evolved into a fine art, and consequently, from the outset of the coming world war, aerial combat would routinely be carried out at altitudes considered remarkable only 20 years earlier. It might even be argued—and has been—that the very existence of new supercharger compressors enabled Frank Whittle to develop his turbojet.

Exotic fuel "cocktails" mixed by brilliant individuals like Rod Banks established the formula for volume production of aviation gasolines with anti-knock properties; these fuels enabled supercharged, high-compression engines to run at high power settings without the risk of detonation. Even the advancement of techniques for liquid cooling led to markedly higher fighter performance by the second world war.

Brute power alone would not have resulted in high speeds without a parallel advance in the principles of drag reduction. Here, the Schneider Trophy races may have made their least recognized contribution. The earliest racers were bluff and squarish, but by the series' end, the airplane had been transformed into a sylph that barely disturbed the air in passing. The fact that airplanes encumbered by huge floats could have attained more than 400 mph in 1931 is sufficient testimony to the competition's role in the education of aerodynamicists.

The Schneider Trophy trail was a strange and tortuous one. In encouraging the talents of such men as Reginald Mitchell and the Rolls-Royce engineers, the competition may not have remained true to Jacques Schneider's conception, but it did lay some of the foundation upon which the Royal Air Force built its victory against the Luftwaffe in the Battle of Britain.

Captain Adams and the Midnight Rangers

For the Hughes mission control team, hanging a communications satellite 22,240 miles over the equator is just another day at the office.

by Steven L. Thompson

Friday, March 20, 1987. Building S67 stands just a few blocks from Los Angeles International Airport, near the intersection of Sepulveda and El Segundo Boulevards. For all the attention it gathers from harried commuters whose cars creep along the arteries, the octagonal building might as well be invisible. Shrouded in the weird atmosphere unique to LAX—a mix of jet fuel fumes, smog, and the smell of sea water—S67 and its parent complex of corporate fortresses are just another group of office buildings to almost everyone who hurries by.

Not to Paul Adams. To him, S67 is home base for a job that takes him and his team of Midnight Rangers all over the world. It's fitting that Adams is based in Southern California, where dreams become reality and reality changes daily. A decade ago neither S67 nor Adams' job existed. Today, some 30 years after Sputnik ushered in the Space Age, jobs like chief flight director for the space and communications division of Hughes Aircraft Company evolve swiftly in the sportiest of all aerospace games: satellite launching.

2217 Universal Time: Paul Adams wheels back from the console in his swivel chair, stands up, surveys the crowded room, and holds up his left hand. The Hughes people know what he's signaling: everyone not mission-essential should get out—*now.* The hubbub that's been building in the flight control room of the Mission Control Center (MCC) dies instantly. Miscellaneous employees, public relations people, and officials from Perumtel, Indonesia's telecommunications company, retreat to the mission management room. Adams sits down and rolls back to the console.

Nearly 2,300 miles to the southeast, a Delta 3920 rocket is poised for launch on Complex 17B at Cape Canaveral Air Force Station in Florida. The countdown for the Delta and its payload, Indonesian communications satellite Palapa B2P, is five minutes and counting. Approximately 30 minutes after liftoff NASA will hand off the mission to Adams and his team, who on Saturday evening will boost the Hughes comsat to 22,240 miles above the island of Borneo. Once Palapa reaches geostationary orbit, Adams' team will activate its communications systems—though that's assuming everything works, and no one in the satellite business makes that assumption. Experience breeds caution: after Palapa B2, the predecessor of B2P, was launched from the space shuttle in February 1984, for example, the McDonnell Douglas payload assist module failed, stranding the satellite in low orbit.

For weeks Adams and the two dozen or so specialists he directs have been preparing for today's launch. During rehearsals technicians have checked and rechecked Adams' mission plan and the linkups with the worldwide network of communications and tracking stations necessary to get Palapa aloft and functioning. But because Hughes has built and launched more than 30 satellites like Palapa, the orbital dynamicists, ground control specialists, flight directors, and spacecraft, communications, and systems engineers have become rather blasé about the imminent liftoff. As the countdown progresses, the ambiance of the MCC remains casual until Adams orders the non-essentials out of the room.

But as the minutes to launch become seconds, stomachs begin to knot. People stare at televisions carrying a live feed from the Cape. The whir of tape drives, the drone of fans, the clicking of switches, the clatter of keyboards, the hiss of comm lines—each of these background noises seems to fade as all eyes focus on the Delta.

In the old days technicians in control rooms at the Cape and New Mexico's White Sands yelled, "Go, baby, go!" when a fragile tube of hopes and hardware rose off the pad on a shaft of flame. Today there are only suppressed exclamations in the Hughes MCC as the Delta lunges into the Florida sky. On Adams' console a digital clock toggles from launch-minus to launch-plus time.

L + 231: The TV watchers relax visibly when the first stage separates. To the uninitiated, a successful separation means a successful mission. But the Hughes operations people know better, and can't relax. They monitor screens full of voltage and amperage values that translate into data that enables a more precise appraisal of how things are going. Wind shear, engine failure, excessive vehicle vibration, propellant sloshing, and guidance system malfunctions are some of the launch glitches that could cause an abort at any second.

L + 236: The liquid-fuel second

Chad Slattery

Wired to a bank of consoles, Paul Adams directs the Hughes team that puts Palapa in its place.

NASA controls Palapa's liftoff, but the Hughes mission control team starts calling the shots 30 minutes later.

stage ignites. Numbers from the tracking stations show it to be almost smack on its assigned path. After its fuel is exhausted eight small thrusters spin up a table supporting the satellite on the payload assist module, or PAM, which replaces the Delta's third stage and will carry the satellite to a highly elliptical orbit.

L + 1213: A solid-fuel rocket on the PAM ignites and burns for 85 seconds, kicking the PAM and its payload into an elliptical transfer orbit at 22,008 mph. Transfer orbit perigee—the closest approach to Earth—is 115 miles; apogee, the farthest point, is 23,040 miles. Spinning at 50 rpm, the satellite separates from the PAM precisely 24 minutes after launch.

Chad Slattery

In the orbital operations room, scientists, systems engineers, and consultants plot Palapa's next move.

L + 1450: Adams announces acquisition of Palapa by a tracking station, then looks up from his mission log and grins. "Dead nominal," he says. The crowd in the center begins to thin; the laymen think the show's over, but it's really just begun for Adams and the mission ops people. Some 28 hours after launch, when Palapa reaches a transfer orbit apogee, the mission control team will fire the apogee motor to place the satellite "on station"—into its permanent 22,240-mile-high circular equatorial orbit. Three weeks of in-orbit testing will follow before control is turned over to the customer.

There will be no stars in this show. It will be a classic team effort: no one person can know everything necessary to loft a piece of equipment the size of a small car to precisely the right spot in space, orient it correctly, and activate all its systems. Neither can a computer. Even now, three decades into the Space Age, it's people who power space programs, not machines.

Watching the MCC team, that's not immediately obvious. Every move they make as they nurse Palapa B2P along its path has been carefully orchestrated, and every command that can be anticipated has been incorporated into the mission plan. It *is* remarkably like a symphony performance, with one vital difference: these performers must play their instruments via remote control. Adams transmits their commands to the spacecraft through a data link operated by systems engineers who, like ships' helmsmen, verify each command before execution.

When the flight plan calls for a thruster to fire, a platform to spin or despin, or an antenna to shift position, Adams first alerts all stations in the MCC that a maneuver is imminent, which allows any mistakes to be detected in time for a quick and economical correction. And in the commercial space business, economics is the driving force.

Economics ultimately comes down to fuel. Palapa B2P arrives at its transfer orbit injection point with almost 1,600 pounds of hydrazine fuel, 1,283 pounds of which will be used to get it on station. The remainder is an energy savings account, withdrawals from which will keep it in position over its anticipated useful life of eight years. The Hughes team knows well that errors mean both time and money lost.

0200 Universal Time: The MCC is largely deserted, but Adams and mission essentials, like "syscom" Dave Norman, are still at their consoles. Norman exemplifies the eclectic mix of the MCC staff. A former Los Angeles policeman, he was forced to quit the city's finest after injuring his back in an altercation with a suspect on PCP. A background in broadcast engineering and an amateur radio hobby landed him at Hughes after he set up communications networks for the MCC as a subcontractor. In matters of communications Norman is Mr. Wizard. He also phones in the pizza order for all hands when the next major operation to get Palapa B2P on station is imminent.

Specialists in "orbops"—orbital operations—call this next step "reor to AMF," short for "reorienting the spacecraft to correct attitude in preparation for apogee motor firing." The "reor" and the firing of the axial thrusters—the "pre-burn"—one hour and 22 minutes later are vital prerequisites to AMF, which for the Hughes team is as crucial as the launch.

Why one hour and 22 minutes? The answer lies in physics and in the minds of the orbops people. Compared to most of us, orbops technicians are mathematical geniuses. They seem a typical cross-section of employees—Bernie Anzel is a fanatical handball player, Chris Cutroneo a car freak, Murray Thompson a health food enthusiast—but to these people quantum mechanics is about as difficult as *Popular Mechanics.* They can visualize, describe, and

When Palapa soared aloft, so did the spirits of Indonesian newsmen (left, inset), dignitaries, and students visiting Cape Canaveral.

then calculate the critical maneuvers of a spacecraft. During a mission they live in the MCC, checking the data the satellite and its tracking stations spew onto computer screens and strip-chart recorders, riding shotgun with Adams to make sure the orbital and attitude numbers are right, and feeding him updated commands to transmit.

The other vital numbers people are the spacecraft systems engineers—"systems guys"—who also reside in the MCC for most of a mission. They are a conduit to the satellite's builders and testers at Hughes, and they hope nobody has to ask them anything, for that would mean something has strayed from dead nominal. So far neither Derek Iwai nor Carl Chen has had much to do—Palapa hums right through Friday evening's reor, pre-burn, and pizza.

Chad Slattery

Orbital dynamicists Mary Cafasso and Jerry Salvatore (right) absorb telemetry and translate it into commands that keep Palapa on course.

Chad Slattery

Dave Norman (left) specializes in systems communications and, during a lull, ordering pizza.

0500 Universal Time: The pizza is gone but a few staffers remain in the MCC even though their shifts ended hours ago. Jokes are traded about Cutroneo's Toyota MR-2, Thompson's granola, Jerry Salvatore's thin brown cigarettes. It is a scene you might witness at any commercial or government mission control facility, with one exception: Hughes' staff is much smaller than the NASA structure that spawned it.

Staffing limits were just one of the problems facing Larry Canin in January 1981, when he accepted Hughes' invitation to reorganize the company's operations. Canin's career path seems unlikely. After dropping out of a Brooklyn high school to join a rodeo as a wild-bull rider, Canin enlisted in the Air Force as a radio operator. By the time he was discharged in 1957 he had earned a general equivalency diploma; an electrical engineering degree from California State University at Los Angeles and a growing interest in aerospace technology boosted him into the rapidly expanding world of space ops. In 1963 he joined NASA in Houston as a flight controller, working under legendary flight director Christopher Kraft.

Canin worked on the Mercury, Gemini, Apollo, Apollo-Soyuz, Skylab, and Viking programs, eventually leaving NASA to become chief flight director for the Jet Propulsion Laboratory team controlling the Viking project. Hughes considered his background ideal to help the company meet its increased launch commitments for the 1980s. Before Canin reorganized operations, Hughes had no formal system in place to coordinate the planning and execution of a customer launch.

Canin's first accomplishment was winning approval to build the MCC. Next he tackled the people problem—one less easily solved because he could not duplicate the NASA structure.

At NASA's Johnson Space Center in Houston, for instance, Larry Bourgeois, deputy chief of the flight director office, has about 300 flight controllers and a dozen flight directors working under him. Most have come straight from universities with degrees in the sciences or engineering. Typically, says Bourgeois, a controller spends a few years at a console in the multi-purpose support room and another 10 years in the flight control room before being considered for a

flight director position.

Canin found that Hughes was overflowing with flight dynamics and systems talent but had few candidates for a professional cadre of controllers and flight directors. Attempts to hire people with console time from NASA's Goddard and Johnson facilities were fruitless—agency employees were loathe to leave secure government jobs. So Canin went to the same well the National Advisory Committee for Aeronautics, NASA's predecessor, had fished in the 1950s. In the days before space job specialization, NACA hired former military pilots as flight controllers.

For Canin, getting good flight directors was crucial to the reorganization of Hughes. Without a seasoned conductor even the greatest orchestra makes less than great music. When things go smoothly the flight director seems to be merely a voice reading aloud from a script. But when things fall apart his is the toughest job of all, mainly because of a phenomenon called "engineer gridlock."

Canin is candid about the problem of highly educated and multi-talented scientists and engineers coming unglued if "their" spacecraft suddenly develops a glitch. When the engineers want to study a situation far too long or when they simply lock horns and refuse to agree on how to correct a problem, a unique type of leadership is required—the type Canin finds in veteran pilots, the best of whom motivate ground and flight crews by persuasion and example rather than browbeating.

These requirements prompted Canin to hire Paul Adams in 1983. Adams was a Boeing 727 and McDonnell Douglas DC-10 captain with 12,000 flight hours, and had made 370 carrier landings as a Navy A-4 Skyhawk pilot during two tours in Vietnam. He had also earned an electrical engineering degree and worked on the Apollo program at North American Rockwell.

Beyond the paper qualifications, Canin saw in Adams the finesse and sensitivity necessary in a corporate flight director for the El Segundo MCC and vital for overseeing a launch from a foreign customer's mission control center.

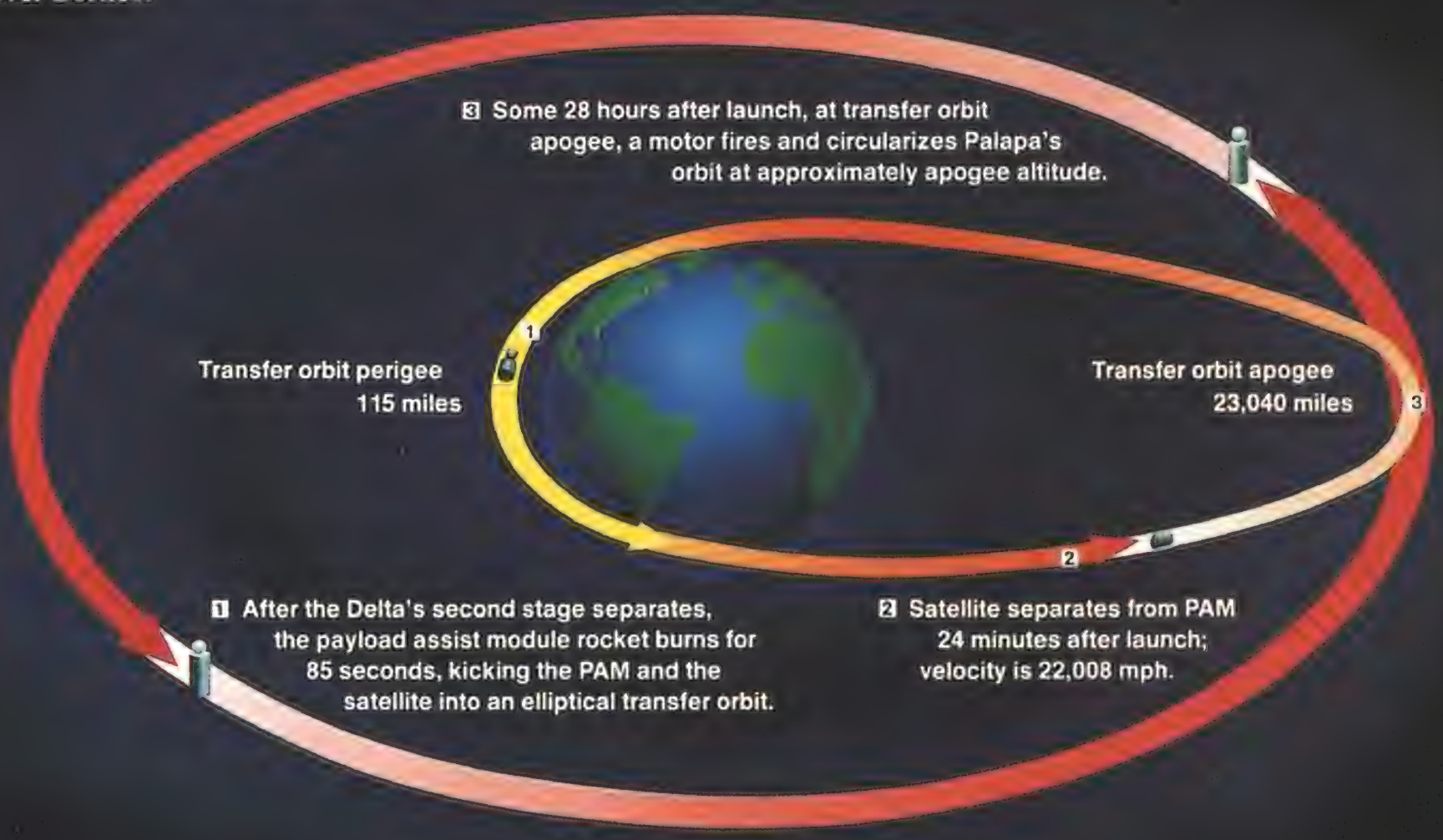
Thursday, September 17, 1987, 0230 Universal Time: The consoles in the Australian National Satellite System (AUSSAT) control center in Belrose, a genteel suburb north of Sydney, seem identical to those in El Segundo. Graham Brown, operations manager for the Belrose station, explains that Hughes worked closely with AUSSAT in designing the station, a partnership that developed when Hughes built and orbited two AUSSAT comsats in 1985.

When a foreign customer buys a Hughes satellite, the contract encom-

Dale Glasgow

Orbital Choreography

The complexities of getting Palapa B2P on station result in a flight path of precise yet surprisingly simple geometry. Palapa, orbiting at 6,879 mph, will appear to hang motionless over Borneo.



Volkswagens in Space

Considering how car-crazy Southern Californians are, it's not surprising that Hughes employees nicknamed the company's rugged, reliable, and hugely successful HS 376 satellites "Volkswagens." In the SoCal car culture the VW Beetle remains the standard by which such virtues are measured, and the HS 376 embodies a similar engineering approach.

Volkswagen pushed the concept of a simple car powered by an air-cooled, rear-mounted engine to its utmost; likewise, the HS 376 is the definitive example of the spin-stabilized satellite. By spinning like a top, the satellite uses gyroscopic force to maintain attitude. Opposing the Beetle were those who believed that liquid cooling is superior to air cooling (and front wheel drive better than rear), while opposing spin stabilization are those who think satellites are better controlled by three-axis stabilization, in which internal gyroscopes are used to sense attitude deviations and thrusters are fired to correct them. Both car and satellite arguments seem unresolvable, there being pros and cons to each approach.

Spin stabilization was the brainchild of Harold Rosen, who was inspired by a 1945 article written by Arthur C. Clarke on the world-changing potential of geostationary satellites. Clarke suggested that a network of three far-flung satellites could provide continuous worldwide radio relay coverage. The potential remained just that throughout the 1950s—no one could figure out how to propel such huge, complex, and uneconomical satellites to an altitude of about 22,000 miles, where at a speed approaching 6,900 mph a satellite in a circular equatorial orbit matches Earth's rotation. At that altitude a satellite can cover about a third of Earth's surface, requiring only minimal tracking by ground stations.

Rosen, now a Hughes vice president, says that while pondering the size requirements he hit upon the idea of reducing the satellite's complexity and therefore its size by using spin as the basis of a stabilization system. Although now as conventional as the Beetle engine, spin stabilization was viewed with considerable skepticism in the early 1960s. But new designs for efficient and lightweight receivers, antennas, and transmitters, along with much cajoling by the aerospace industry, persuaded NASA and the Department of Defense to fund the first spin-stabilized satellite. In February 1963 Syncom I blew up when its apogee motor fired to kick it into geostationary orbit. Syncom II, launched five months later, served as a test bed for developing launch and communications techniques. The following year Syncom III was positioned over the Pacific in geostationary orbit; it carried the first live TV coverage of the Tokyo Olympics.

The tendency of a spinning mass to wobble—called nutation—is the nemesis of spin-stabilized satellites. Ingenious applications of gyroscopic theory have resulted in sophisticated methods of controlling nutation, such as the Gyrostat system Hughes developed in the late 1960s. The Gyrostat uses motorized rotors to control energy dissipation. This approach unlocked constraints on the size of spin-stabilized comsats, and the increased size permitted increased capacity.

Hughes Aircraft Company

Hughes has built 32 HS 376 satellites for customers around the world.

But greater size also demands greater power. So Hughes came up with a way to compress a satellite for launch by slipping one half over the other and telescoping it after deployment, more than doubling allowable height while permitting it to be launched on midsize Ariane and Delta boosters rather than relying solely on heavy-lift boosters and the space shuttle. Lured by the satellite's economy, corporate and government customers from the United States, Canada, Australia, Brazil, Mexico, Indonesia, and Great Britain have commissioned 32 versions of the HS 376.

Hughes officials are candid about the 376's limitations and have built upscale models, both Gyrostat and three-axis. Chief among them is the mammoth HS 393, a "widebody" in comsatspeak. One of the first to sign up for the new model was Satellite Business Systems, a U.S. communications company that was also the first HS 376 customer. As an old ad put it, "Ask the man who owns one."

—Steven L. Thompson

passes more than simply building a piece of equipment and shipping it to a launch site. Hughes also helps build the ground stations that control the satellites, trains the staff, and sends a mission operations team to the customer's control center to get the satellite into the proper orbit.

Spacefaring companies like Hughes, Ford Aerospace, and RCA have become more than just spacecraft manufacturers—they have become a cultural force, exporters of intangibles. They are contemporary versions of the 18th century European East India Companies, which were chartered to exploit lands discovered by government-funded explorers. Those companies are now indicted for ushering in the era of European colonialism, but they also spurred technological and economic growth. In doing so they accelerated the shrinking of the world, a process the 30-plus Hughes comsats continue. Geostationary comsats enable instantaneous communication and television broadcasting over vast areas at a fraction of the cost of ground-based networks, bringing remote communities into the international mainstream.

In less than an hour, AUSSAT K1 and K2 will be joined by K3, now approaching its third transfer orbit apogee. Flight director-in-training Orv Hett, another former military and airline pilot, is at the console while Adams supervises. Hett, hired to augment the Hughes team as missions increase, is learning the ropes the way Adams did: on the job. Adams considers it a lucky break that K3's launch schedule has slipped again; the delay allows him to give Hett more console time.

Originally scheduled to go up on an Ariane 3 from Kourou, French Guiana, in September 1986, K3's launch had been postponed time and time again after a May 1986 ignition failure prompted a redesign of the third-stage engine. There had been so many delays it surprised no one when six minutes before yesterday's liftoff the Kourou launch director halted the countdown because of a suspicious temperature reading in a fuel umbilical arm. At Belrose, halfway around the world from the launch site, wisecracks flew between the Aussies and Yanks at the expense of the French. But when the minutes became an hour and the launch window narrowed to less than 30 minutes, the jokes stopped. Eighty-nine seconds before the window slammed shut, Ariane V19 roared skyward, carrying AUSSAT K3 to transfer orbit.

For Adams the launch involved the meshing of two cultures. In cautioning the Australian console crew about their rising rambunctiousness, he walked a fine line between rebuke and humor in order to refocus the young engineers on their tasks. When Kourou handed over the mission to Belrose, the easygoing Australians teamed up with their more experienced American colleagues and settled down to business. Orv Hett and Graham Brown were seated side by side at the console under Adams' tutelage as AMF approached. They will later pair up as the mission's Midnight Rangers, charged with the tedious but vital task of "ranging" K3 through the night to ensure it is precisely on track.

John Marmaras/Woodfin Camp

During the K3 launch, Adams protégé Orv Hett (left) got plenty of console time at AUSSAT's MCC.

At 60 seconds to AMF, it's suddenly clear that the complex process of building and orbiting satellites consists mainly of long periods of inaction, even boredom, interspersed with moments of intense mental and electronic activity. The physics of hurling a man-made object thousands of miles into space remain a constant, as does the question of whether man can manage it. Each time we attempt it we must demonstrate our ability, or lack thereof, anew. Adams, a veteran of 16 Hughes missions, cryptically remarks, "One's a lot like another, but they're all different."

Adams orders the AMF signal sent to the rocket motor. Silence blankets the control center. Three seconds after execution, a voice from the orbops room announces, "We have Doppler." The satellite's signal has shifted frequency, indicating that the spacecraft is accelerating. Ninety seconds later the voice says, "We have a Doppler shift of 25.24 Hertz and a burn time of 54 seconds." In orbops they measure, analyze, and compute. A few moments later, Chris Cutroneo hustles through the door to the control room and hands Adams a sheet of paper. Adams reads it and finally smiles. "Dead nominal," he says.

Adams peels off his headset and announces that it's time for lunch. AUSSAT K3, more than 22,000 miles out, goes into geostationary orbit like a cross-country locomotive. The relief in the control center is palpable.

And out on Forest Way, just a hundred yards from the station's huge antennas, people bustle by, as oblivious to the AUSSAT EARTH STATION sign as the Sepulveda commuters are to Building S67. That suits Adams and the Midnight Rangers just fine. It's business as usual in the space business.

Hover Story

One minute and three meters to glory.

by John Grossmann

Photographs by Christopher Casler

Friday night has long ago given way to Saturday morning, and the California Polytechnic State University campus in San Luis Obispo is quiet. Well, almost quiet. Inside the gym, a group of students and a lone professor are yelling at the top of their lungs, confirming a lesser known law of aerodynamics: it's hard to keep from cheerleading when you're trying to make aviation history.

"Hit it. Hit it."

"Go. Go. Go."

If their cheers are simple, their goal is anything but. Now that the Gossa-

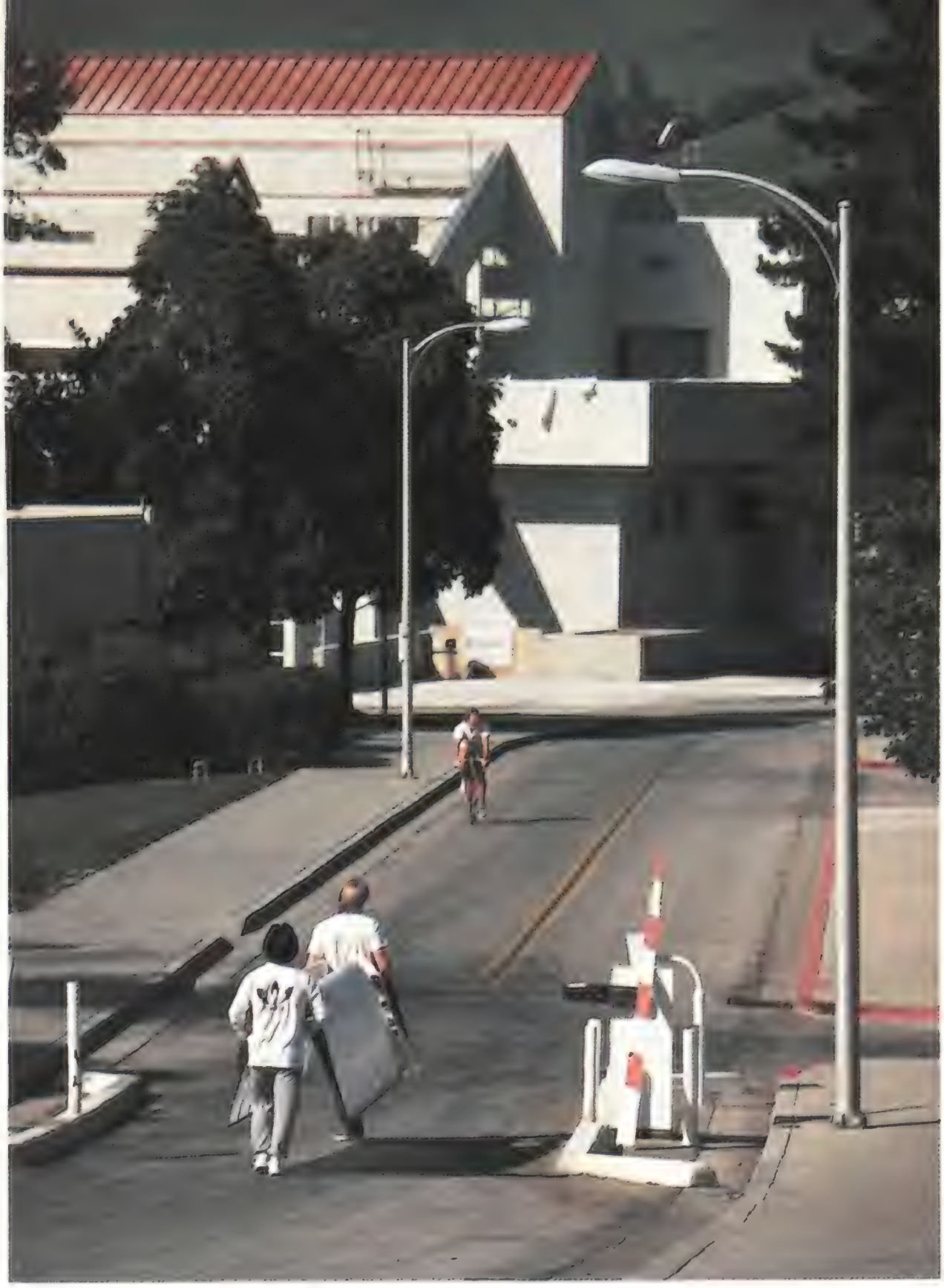
Cal Poly students confer, engine-to-engineer, as the ground crew awaits yet another helicopter flight test.

mers *Condor* and *Albatross* have been pedaled into the record books and *Daedalus* has claimed the distance crown (see "How many light bulbs . . . ?" p. 94), the next challenge for human-powered flight is one that's been teasing engineers for centuries: the liftoff of a human-powered helicopter.

"Go-ohhh." The cheering subsides like a phonograph losing power midplay. The gigantic rotors of an experimental craft called *Da Vinci* whirl slowly to a stop. From a housing of tubes at their hub, the engine, a panting cyclist, steps out to stretch his legs while the ground crew makes some adjustments before the next attempt at flight. It's 1:10 a.m., with only a week left before the 1986 Thanksgiving break. There's talk of adjusting the rotors so they take a bigger bite of air.

Since 1483, the date attributed to Leonardo da Vinci's now-famous notebook sketch of a human-powered "helix," mankind has been both beguiled and bedeviled by the notion of helicopters. Borrowing from the Greek physicist and mathematician Archimedes, da

Jim Freitas works on the spool that winds in the string that turns the propellers that pull the rotors.



Rotor sections get a lift across campus. Transporting the old 50-foot rotors required more hands and no wind.

Vinci predicted "said helix is able to make a screw in the air and to climb high." How easily said. And how hard to do, for it's now known that the power required to lift one pound of weight is between two and three times greater for a helicopter built to hover than for an airplane built to cruise.

A contemporary assessment of the challenge was made in 1979, when the American Helicopter Society asked Richard Bennett, an engineer with Bell Helicopter Textron, Inc. in Fort Worth, to chair a committee to study the feasibility of human-powered vertical flight. Bennett, who in his words has "spent the last 20 years writing helicopter equations," considered some rough numbers. Starting with the belief that a fit cyclist, pedaling himself to collapse, can generate one horsepower for around a minute, he figured the cyclist could generate half that power virtually indefinitely. Bennett split the difference and assumed a 0.75-horsepower engine. Next he estimated two more numbers—130 pounds for the cyclist and 120 pounds for the helicopter. That essentially framed his question: Can you design a helicopter that can generate 250 pounds of lift from 0.75 horsepower?

A few months later, in 1980, the American Helicopter Society announced the Igor I. Sikorsky Human Powered Helicopter Competition: $10,000, with a nod to the father of the modern helicopter, to anyone who could keep a human-powered helicopter hovering within a 10-meter square for one minute and at some point during the flight reach an altitude of three meters. Since then, the society has mailed out scores of applications worldwide and has raised the prize money, first to $15,000, more recently to $20,000.

"Everybody ready? Video cameras?" At the hub of the Cal Poly craft, a new one dubbed *Da Vinci II,* cyclist Andres Eulate toes the pedals. This flight test is being made in a cavernous beige building near Long Beach Airport where McDonnell Douglas will soon begin assembling the first C-17 military airlifters. During a year's hiatus in flight tests, the students extended the rotors of their helicopter and designed themselves right out of the Cal Poly gym. The closest place wide enough to accommodate the new rotors was this hangar—at 1.1 million square feet it's big enough, say the folks at McDonnell Douglas, to house 64 Goodyear blimps. Some 50 feet from Eulate and 100 feet

Finishing touches: Bob Guttieri smoothes a plastic membrane over the balsa wood "flaperon."

A patch to stiffen an injured rotor rib is first traced, then cut from a piece of carbon-fiber cloth.

Heidi Hendrickson files an aluminum sleeve that connects two sections of the carbon graphite spar.

from each other, two members of the ground crew raise the ends of the ungainly rotor blades to shoulder height in preparation.

"Let's go."

Eulate pedals. Propellers on the leading edge of each rotor tip whir, then the rotors start a sluggish revolution, counterclockwise. Two pairs of sneakers pound the floor. The rotors lift up and out of the hands of the circling runners.

"Pick it up. Kick it. Faster."

"Up. Up. UP."

If helicopter lift equations could somehow convert enthusiasm to horsepower, the Sikorsky prize would be awarded right here. But this flight test is stopped after 30 seconds—best to save the 140-pound engine for the next attempt at getting himself and the 150-pound *Da Vinci II* airborne. As it has so many times before, a curious and somehow charming call goes out: "Rewind the string."

The string is *Da Vinci*'s ingeniously simple transmission, a polyurethane-based fiber wound around spools to produce a torqueless drive. Envision a spool at each rotor tip, the string unwinding hubward inside each rotor through a four-inch-wide carbon graphite tube. The tube functions as a support spar and also joins the rotors to the pedal portion of the craft. The ends of the string are tied to a take-up spool attached to the cyclist's crank. When he pedals he reels in both strings, turning the spools and thereby rotating the props fixed to their lead ends. These smaller blades, pulling on the rotors' tips, set the big blades whirling.

As the string is rewound, the ground crew confers about insufficient rotor rpms and changing the angle of attack. A game plan has been committed to paper, one that calls for a few more data tests on these 50-foot rotors, but everybody's simply too itchy. The effort to gain access to an indoor space of this size and the 250-mile drive from San Luis Obispo were made with one thing in mind. Like an impatient quarterback tired of hand-offs and screen passes, the team decides to go for the bomb. "Let's put on the fourth sections of the blades."

In the not-so-old days of flight testing in the Cal Poly gym, beginning in 1981 and running forward through several waves of graduating aeronautical engineering students, the machine with the mere 50-foot rotors came close to putting a little daylight between itself and the tipoff circle on the school's basketball court. Videotapes of those flight tests show the craft's skeletal gondola skittering on the gym floor on a couple of occasions. That craft, now known as *Da Vinci I,* persevered until late 1986.

"We kept hoping it would fly, but we were putting our hearts into somebody else's machine, by then broken and fixed so many times it was ratty," says Rob Faye, a McDonnell Douglas engineer who, like a handful of the "core committed," was then a junior. No doubt intending to force their resolve to build their own craft, the students veered off into sacrilege. In place of a thick-thighed cyclist they strapped a two-horsepower motor into *Da Vinci*'s hub and ran an extension cord to a wall socket. Plugged in, the helicopter rose about two feet before it crashed. It was R.I.P. for the old rotors. (Well, almost. One spar was commandeered and cut to support the flapping dragon wings on the school's entry in this year's Tournament of Roses Parade.)

Rededicated to human power, the Cal Poly students wasted no time. Faye, who'd previously worked for NASA as a student intern, spent a weekend at NASA's Ames Research Center beside helicopter research engineer Fort Felker, running scores of possible designs through the agency's CAMRAD

Team members prepare to test airflow around a propeller by first testing the smoke supply.

(comprehensive analytical model of rotorcraft aerodynamics and dynamics) computer program for rotor analysis. Tod Palm mailed well over 100 letters to corporations, seeking donations of materials. And when U.S. Polymeric came through with $20,000 worth of ultralight carbon graphite, building began in earnest.

CAMRAD narrowed *Da Vinci's* rotors and lengthened them by a third. But experience told the students what the computer could not: that they'd be crazy to try to build, store, and transport rotors stretching nearly 70 feet. So they built them in 16-foot sections, interlocking via the internal carbon graphite spar. They also added a pair of fixed landing arms to the rotor tips to help protect the propellers from the impact of landing.

One constant throughout *Da Vinci's* several design and personnel changes has been faculty advisor William Patterson, an amiable professor of mechanical engineering. "This is it. Pray," he says to Faye when the fourth sections are finally on. The *Da Vinci II* stands assembled for the first time, its 140-foot rotor diameter impressive even when stationary.

"Picture time." The group assembles in front of its creation. Cameras flash away. Then Eulate takes his seat and clamps his cycling shoes on the pedals. Patterson, the eternal optimist, scrounges up a length of rope and ties one end to the gondola and keeps a grip on the other. "Don't want him hitting the ceiling," he says.

"Are we ready?"

"Kick it, Andres. Kick it."

"Go. Go."

The rotors begin revolving and rising, high, higher at the tips, arcing up more and more, taking on the shape of a huge bowl. Eulate is pedaling furiously. "It's bouncing. Look at it, it's bouncing," somebody yells as the gondola gets lighter and lighter . . . but doesn't lift off. The test is cut short. Eulate slackens his pedaling. The rotors slow nicely and the runners catch the tips to help cushion the stress of descent. "It was mega-coning," says senior Scott Larwood.

The coning was predicted and, as everybody knows, will have to be reduced. A quick viewing of the videotape shows the blades coning up as much as 35 degrees from horizontal. Larwood does some calculations and figures that this amount of coning could be reducing lift by as much as one-third by curbing helpful "ground effect," a cushion of lift provided by the air compressed between the rotor and the ground. Additionally, the videotape shows the rotors turning fewer than four times per minute. They need around 6 rpms to fly.

A runner on crash alert trails the fragile propeller as the props pull Da Vinci II's *70-foot rotors to life.*

Saturday afternoon is waning, and a good number of the students are already running late for another commitment. Tod Palm is getting married a few towns away (some things do take precedence). A couple of tears in the rotor skin must be patched. And a guy wire system must be rigged to restrain the coning. Next flight test: first thing Sunday morning.

Says Patterson, "I really think we've got a good chance of flying, but then I've been saying we're going to take off for years. It's as much a matter of student perseverance and enthusiasm as anything else. It's thousands and thousands of man-hours. That's why I think anybody who attempts one of these on his own is a very brave individual."

It is unlikely either J. Curtis Barnes or Peter Zwaan considers himself brave. Balmy, perhaps.

Barnes, a 75-year-old former Disney animator, air freight operator, and pear grower, reports he's on his sixth generation of *Tipsy Bee,* a craft named for his old brand of fruit. Says Barnes, "We hadn't used up all the stationery, and the name seemed to fit."

Barnes was in fact already trying to fly a human-powered helicopter in the field in back of his home in Medford, Oregon, before he heard of the Sikorsky prize. Since then he's shifted to a double-rotor system in order to jettison a tail rotor that required some 10 percent of his power. He also repositioned his cyclist. Like the Cal Poly crew, the creators of a British craft called *Vertigo,* and the designer of a Japanese version nicknamed *A Day Flyer,* Barnes at first positioned his rider higher than the rotors. Everybody's theory: Get the rotor blades as low as possible to take advantage of ground effect. Says a more experienced Barnes: "You can get *too* close to the ground."

His pilot of choice these days is his

Nick Gunderson

Carrie Barnes, volleyball player and Tipsy Bee *engine, watches her granddad groom Mylar-coated rotors.*

Nick Gunderson

Looking a little like a clothesline pole, the Tipsy Bee *gets its rotors adjusted in Barnes' backyard.*

16-year-old granddaughter, Carrie Barnes, a 96-pound volleyball player. He confesses he's still making do with six-year-old blades that have endured a crash or two. But, he adds enthusiastically, he's about to move indoors for the first time. "As soon as they get the watermelons out" of a local cold storage building, Barnes will haul his 100-pound craft inside, where he can escape the sudden gusts of wind that have menaced his flight tests in the past. His expenses to date? "I wouldn't even want to guess," he says, adding that he wouldn't mind terribly if somebody beat him to the Sikorsky prize. "At least," he grins, "I could get on with my life."

Peter Zwaan, for one, would be happy to oblige him. Zwaan, a 31-year-old former airplane mechanic now studying industrial design at the Art Center College of Design in Pasadena, searched for months for an indoor site where he could test his design, a co-axial system with one set of blades atop another on a mast, one spinning clockwise, the other counterclockwise. The gearing is a labyrinthine arrangement of sprockets and plastic chain.

Zwaan finally got access to a hangar, one belonging to a helicopter company near his home in eastern Pennsylvania. He paid the plane fare from Portland, Maine, for his wife's cousin, a 115-pound bicycle racer. He borrowed scaffolding. Then he set about assembling the craft he refers to as *Leo.* He never expected it to soar. With its mast reaching 23 feet high, it was barely two feet from the ceiling of the hangar. Sadly, though, Zwaan didn't even get to see his rotors turn. In keeping the craft's weight in the neighborhood of 60 pounds, he under-engineered the support trusses for the blades, and after hours of rigging piano wire from the mast to the wingtips, he watched helplessly as first one blade, then another, collapsed to the ground like broken tree limbs.

When Zwaan moved to California a year ago he took *Leo*'s pedal assembly with him. Within weeks he'd redesigned his craft and cut the height and rotor size in half. The new design called for six blades, counter-rotating, three atop

Randa Bishop

three. And rotate they did, with an energetic rider, 110-pound triathlete Tim Comstock, providing the horsepower. Slippage in one of the chains, a problem that will need correcting, may well have kept the craft grounded. But Zwaan was nonetheless pleased, even more so after Comstock dismounted. That's when Zwaan happened to turn *Leo*'s pedals by hand and watched his craft rise a couple of inches off the ground.

Sunday morning in Long Beach. Those who spent the night in sleeping bags in the C-17 building are joined shortly

after 8 a.m. by the rest of the crew, more than a few of them a little slow on the uptake after an obviously long night of wedding celebration. Work resumes, a bit sluggishly at first.

"The key is rpms. We're not getting enough," says Jim Freitas, the current president of the Cal Poly American Helicopter Society chapter. The reason could be the extreme coning. Rob Bernier is intently rigging the guy wire system.

An earlier Tipsy Bee *sported a tail rotor and an engine perched atop the main blades. It didn't work.*

By 2:55 *Da Vinci* resembles a princess before a ball—the object of many hands and much grooming. There's careful smoothing of the plastic patches covering the joints where the rotor sections connect. Flap checks. Propeller checks.

Eulate crouches down and slides aboard. For the first time, he wears a helmet.

"All right? Looks good."

"Hit it. Go. Go."

The cheering begins anew. The crank rpms build to 100. The rotors are turning, faster than before. They are showing markedly less coning.

Peter Zwaan and his wife study plans for the helicopter they hope will win the $20,000 Sikorsky prize.

"Go. Go. Come on Andres."

The gondola starts getting lighter, rocking about unsteadily as Eulate pedals for all he's worth. Suddenly the front post of *Da Vinci*'s base lifts up. A moment later the post beneath Eulate's seat leaves the floor.

"Oh my God."

"Slow it. Slow it. Let it down easy."

The building resounds with screams of delight. War whoops. The students converge near the hub like World Series victors on the pitcher's mound, hugging and backslapping. "Nice cables," Freitas says to Bernier. Moments later everybody eagerly huddles around a TV set to watch the videotape of the test. The tape does indeed show the central housing bouncing and the front and back ends lifting off—but not simultaneously. They did not make history. Just progress.

More viewing of the tape and a few calculations indicate that the rotors made it to 5.13 rpms. "We're right on the edge now," says Faye. "Five and a half rpms is flying."

But will they?

Richard Bennett, whose calculations helped launch the contest, wouldn't bet on it. "Maybe I'm a pessimist, but I personally doubt anyone will be able to do it," he says. "There are so many problems. Just flying a helicopter can be like rubbing your stomach and patting your head. This is like rubbing your stomach and patting your head while running a four-minute mile."

"It's not obviously impossible," offers R.W. Prouty. "That's kind of a weak endorsement, I'll admit, but I think somebody will do it." Prouty, a columnist for *Rotor & Wing* magazine and an engineer recently retired from the McDonnell Douglas Helicopter Company in Mesa, Arizona, agrees with the Cal Poly team's choice of huge rotors. "You've got to handle an awful lot of air if you're going to produce lift with such a small amount of power."

Zwaan got Leo *to lift off* sans *cyclist, but with a rider aboard the craft stays stubbornly earthbound.*

Patterson, if pressed, will admit to having invested more than $11,000 in the project. Many of the students have also kicked in money, though lately they've tried to offset some of their expenses by selling *Da Vinci* T-shirts, at $10 each. "Sixty thousand dollars' worth of materials, 100,000 man-

hours—to win a $20,000 prize," mused Patterson, and that was back while they were flight testing *Da Vinci I.* Still, he believes everything will finally come together.

"Come on. Come on."

"Hit it. Hit it."

Again, *Da Vinci*'s rotors start generating momentum and lift, but unevenly. The front of the gondola jerks upward at least six inches.

Then it happens. Just short of one revolution of the blades, there's a sound like a gunshot. One of the support spars for the guy wires has snapped. The stricken blade drops. The landing arm gives way on impact and the prop breaks apart, a chunk of it skittering about 20 feet toward the central housing. The other blade, which shot upward in Newtonian response, descends more slowly, and is cushioned by an alert runner just short of a second crash.

Everybody stops. For a time they stare at their wounded bird. Then at each other. Gradually the inevitable debate heats up, building finally to a show-of-hands vote.

"Okay, let's break this baby down."

As the students take the rotors apart, Patterson says, in the spirit of Churchill, "We'll never give up. We'll never give up. We'll never give up."

Steve Finberg

How many light bulbs does it take to fly a bicycle racer across the Sea of Crete?

For most of the last two years John Langford and a corps of engineers channeled an impressive amount of energy—the zeal of dozens of students, the financial might of United Technologies and Anheuser-Busch, and the muscle of several triathletes—into an airplane that operated on only 200 watts (0.25 horsepower). The airplane, *Daedalus,* set the world distance record for human-powered flight on April 23. Powered only by the pedaling of cyclist Kanellos Kanellopoulos, *Daedalus* duplicated the 74-mile trip across the Sea of Crete made by its namesake, the mythical hero who fled King Minos on handmade wings.

Human-powered airplanes may be slow, but they've certainly come a long way in a short time. Only 12 years ago the Royal Aeronautical Society in England was wondering if anyone would ever win its first Kremer Prize: £50,000 for flying a mere mile-long figure-eight course in a human-powered craft. In 1977 Paul MacCready's *Gossamer Condor* did, beating the *Chrysalis,* a craft being flight tested at MIT by a team that included Langford. Langford and the MIT group bounced back in 1984 to win a $33,000 Kremer prize for building the world's fastest human-powered airplane, the *Monarch.* The *Monarch* captured the title by roaring along at about 20 mph for three minutes.

Having conquered speed, the engineers turned their attention to distance. MacCready's *Gossamer Albatross* had already crossed the English Channel. The Atlantic Ocean was out of the question. Then Langford and his colleagues thought of the story that, as he says, "is in the first chapter of nearly every anthology of flight."

To make sure they'd have a pilot who could go the Daedalus distance, about three times that of the 1979 English Channel crossing, the team recruited and trained five world-class bicycle racers, including Kanellopoulos, a member of the Greek Olympic cycling team. In order to lift and move the 70-pound *Daedalus* and his own weight, which was approximately twice that of the aircraft, Kanellopoulos had to produce 1.5 watts of mechanical power for every pound he weighed. This effort required his heart to beat about 150 times a minute to pump the necessary blood to his muscles. In order to complete the trip from Crete to Santorini, he had to sustain that heart rate for three hours and 54 minutes.

Kanellopoulos and the other four cyclists were on a rotating training schedule so that one of them would be ready on the first day that the weather looked right. Steven Bussolari, who teaches aerospace human factors in aeronautics and astronautics at MIT, managed the training, juggling his bicycle racers as a baseball manager in a pennant race juggles his starting pitchers.

Pushing the limits of human endurance provides only marginal increases in power, however; pushing the limits of human ingenuity promised the team a higher yield. In order to compensate for their low-energy engine, they built a long, efficient wing and used every trick they could conjure to reduce drag and weight.

Mark Drela, a veteran of the *Monarch* project who is in charge of aerodynamic design, shaped the airfoil for maximum lift and minimum drag with the help of a computer program he wrote. Wide-eyed, wispy-haired, and taciturn, Drela is a classic MIT engineer: his research specialty is computational fluid dynamics and he loves to build things. "This is really hard to do, that's sort of the key thing," Drela says.

Juan Cruz, another veteran of the *Monarch,* left a steady job at Beech Aircraft to design and build the wing structure. The design uses a main spar far forward in the wing and a second spar behind. This minimal spar design is as conventional in aeronautics as see-through tuxedos would be in the fashion world. Wing structure is usually robust; wings must be able to withstand powerful forces in flight. To reduce the risk of a midair failure and subsequent crash, the team assembled the wing, suspended it in midair, and hung half-full soda bottles from it. By varying the amount of liquid in the bottles, they could simulate different degrees of stress. The wings held, and the project moved ahead. As Cruz puts it, a great deal of the airplane is assembled according to the TLAR philosophy—"that looks about right." "You design the major parts, the rest of it sort of gets designed as you go," he explains.

Weight—more correctly, the lack of it—guided the selection of materials and many of the design decisions. The ribs and leading edges of the wings are made of polystyrene foam, as is the propeller, which is 11 feet long and weighs only 28 ounces. One-quarter of its weight is paint. The cranks connecting the pedals to the gearboxes were machined down and drilled through to reduce their weight; lines of holes march up their sides, giving them the appearance of shiny Swiss cheese. The Kevlar cockpit is 1/100 of an inch thick.

Once the various pieces were ready, the team assembled the aircraft in the hangar of MIT's Lincoln Laboratory Flight Facility. Enclosed by the white walls and girders of the hangar, the work area resembled an intensive care ward for immense insects. There, surrounded by a variety of small airplanes sporting bumps and pods housing sophisticated electronic components, the *Daedalus,* dissected into half a dozen large pieces and many smaller ones, awaited treatment. In this state, its huge transparent wings gave it the appearance of a giant dragonfly that had been pulled apart. On a nearby cart sat the doctors' tools: medical gloves, rivets, a vacuum pump, needle-nose pliers, Kevlar string, goggles, spray-on glue, quick-set epoxy, M&Ms, empty Coke cans, and a pterodactyl hat.

Daedalus rolled out of the laboratory on October 20, 1987, and in November migrated to the California desert. Flight tests and training were conducted at NASA's Ames-Dryden Test Facility, where the prototype aircraft, the *Michelob Light Eagle,* had broken the distance record earlier that year. Last February 7, *Daedalus* crunched into the ground during a training flight, setting back the projected Greek flight date by about two weeks. A second *Daedalus,* built for just such a contingency, was exchanged for the broken airplane, which was transported back to Boston and repaired.

Kanellopoulos was forced to crash-land the backup craft 30 feet from the beach on the island of Santorini because of gusting winds. Langford called the damage extensive and doubted that the airplane would be rebuilt.

—Frank Lowenstein

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by J. Kelly Beatty

Commemorating Cosmonautics

Moscow's monuments reflect the Soviet Union's reverence for space travel.

Roger Ressmeyer

A cosmonaut mannequin stands guard over the Cosmonaut Memorial's subscale model of a Vostok re-entry capsule.

The heroic stature attributed to Soviet space explorers is reflected in this frieze on the Cosmonaut Memorial.

Crops may fail and policies founder, but the Soviet Union's ongoing space triumphs remain an obvious source of pride among its people. In the absence of sanctioned religion, the attention lavished upon cosmonauts has risen to near-worshipful proportions. The space heroes are not merely respected, they are also adored. Americans experienced this kind of emotional rush over the seven Mercury astronauts, but in the Soviet Union it continues today. "Cosmonauts are gods," says Frederick C. Durant III, a long-time observer of the Soviet space program. If so, the temples to these gods are the space-related monuments, museums, and memorials scattered throughout Moscow.

Atop an 80-foot spire beside Lenin Avenue in Moscow's southwest district stands a 20-foot-tall likeness of Yuri Alekseyevich Gagarin, well muscled and angular. In the distance are Moscow's ceremonial entrance gates, the start of the "path of glory" into the city taken by motorcades of successful cosmonauts. Near the spire's base lies a replica of the Vostok 1 capsule that took Gagarin on a single 108-minute loop around Earth on April 12, 1961.

Gagarin's 1968 death in a training jet crash sent the entire nation into mourning. "Our Yuri," as he is often called, was cremated and enshrined in the Kremlin Wall during a televised state funeral. The statue was erected in 1971 to commemorate the 10th anniversary of his flight.

James Sugar/Black Star

An impressive collection of tributes to Soviet space prowess is housed just across Prospekt Mira (the Avenue of Peace) from the Kosmos Hotel. The hotel is immense (1,777 rooms), relatively modern (it was built by the French for the 1980 Olympics), and located well north of the city center; visiting Americans are frequently assigned lodging in this vast arc of glass and concrete. An astronomical motif dominates the lobby, and the bar, not surprisingly, is named Sputnik.

Rooms with a good view overlook the Cosmonaut Memorial, another gleaming spire that arches 295 feet into the sky. Most of this titanium-clad structure represents the exhaust plume of the tiny rocket, racing skyward, at its pinnacle. On its base, a stone frieze depicts a space-suited cosmonaut ascending a stairway, encouraged by determined, muscular representatives from labor and academia.

A Museum of Cosmonautics is situated beneath the memorial. Maintained by the Ministry of Culture, it is open only sporadically, when small groups are ushered through, and this limits the number of visitors to around 130,000 a year. Museum-goers must exchange their shoes for pairs of oddly designed slippers upon entering, presumably to protect the plush blue carpet from the grit of Moscow's streets. The number of people admitted at a time, perhaps three dozen, is governed solely by the number of slippers. I was one of the last to go in, so I had to pick through the dregs. As the tour began I shuffled along clumsily in a huge pair.

The guide's Russian monolog, unintelligible to me, was obviously well rehearsed. After a few minutes I tuned out his drone and began to take in the sights. The main display room was dark, with spotlights accentuating space capsules, suits, and other paraphernalia. Alexei Leonov's 1965 spacewalk—the first—rated a dedicated display, as did robot craft dispatched to the moon and Venus. A couple of video screens showed highlights of Soviet space missions. But all these were secondary to the real focus of attention, which took up the entire front wall. No word describes it better than "shrine." A cosmonaut mannequin, bathed in bright light, stood at attention, his arms outstretched in greeting. In front of him hung a model of Sputnik 1. Directly behind

Roger Ressmeyer

An A-1 Vostok launcher stationed in front of the Cosmos Pavilion establishes the museum's theme.

Barry Fitzgerald

The amenities at the Cosmos Pavilion may not meet Western expectations, but visitors enjoy access to models of spacecraft, such as the Luna 24.

was a spherical, wrought-iron sculpture depicting the signs of the zodiac, and behind that an illuminated wall of stained-glass stars and galaxies symbolizing the infinity of the universe.

Standing guard outside the memorial is the sculpted likeness of Konstantin Eduardovich Tsiolkovski, a rural schoolmaster who formulated the principles of rocket-powered space travel. His work was published in 1903, the year the Wright brothers' *Flyer* was just taking wing on the shores of North Carolina.

Tsiolkovski perfected his rigorous calculations in the town of Kaluga, about 100 miles southwest of Moscow. The modest house where he lived and studied is now a museum, but in three extended trips to the Soviet Union I never got to Kaluga. That requires a separate travel visa, and getting ones for Moscow proved difficult enough. Soviet officials kept insisting *vozmozhno*—it is possible—but in practice access is strictly limited.

But there was plenty to see back in Moscow. Near the Cosmonaut Memorial, a collection of rockets and space artifacts serves as part of a large "theme park" called the Exhibition of the Achievements of the National Economy, or, more commonly, VDNKh (its Russian acronym). The VDNKh, a 553-acre home for some 80 pavilions that reflect the diversity of the Soviet Union, is to Moscow what the Smithsonian Institution is to Washington. A space exhibit, the Cosmos Pavilion, was added in 1966, and today it boasts more than 100,000 square feet of floor space and draws eight to nine million visitors a year. Summer brings throngs of local citizens to the space exhibit, but in winter the crowds dwindle—the pavilion lacks a heating system. Yet even then Soviet parents accompany fur-bundled children from one display to the next. The few foreign tourists who venture to the VDNKh can join walking tours conducted by students from Moscow's language schools.

Just beyond the pavilion entrance a full-scale A-1 rocket stands on an elevated platform. Like many of its U.S. counterparts, the A-1 evolved from a ballistic missile. But rather than toying with ever more advanced power plants to improve performance, Soviet engineers simply clustered 20 off-the-shelf

Barry Fitzgerald

Children throng to the pavilion in summer; the lack of heating makes the hall less inviting in winter.

Barry Fitzgerald

One of the Lunas' predecessors, Lunakhod 2 roved the lunar surface under remote control from Earth in 1973.

engines into one vehicle. With an abundance of thrust, the A-1 propelled Gagarin and the Soviet Union into Space Age prominence.

The pavilion itself, built in the 1930s, is a long, open hall with an arched glass roof and a large rotunda at one end. Spacecraft line both sides of the hall like soldiers in review, arranged roughly according to the types of missions they flew. Centered above the entrance is a model of Sputnik 1, the silvery, whiskered sphere that started it all.

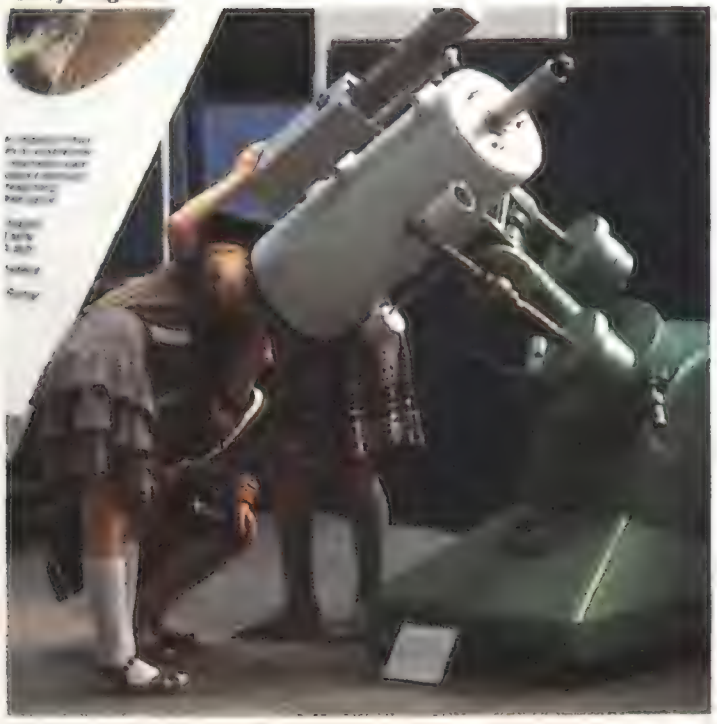
Unfortunately, the Cosmos Pavilion doesn't seem well suited to storing irreplaceable space artifacts. Some of the panes in the glass roof are broken, and pigeons have taken up residence on the rafters. Down at ground level, the daily cleaning includes hosing down the bare concrete floor. Consequently, most of the displays are models, although some spacesuits and other genuine items can be found inside glass cases. Cathleen Lewis, who coordinates the National Air and Space Museum's foreign loans of space artifacts, says the pavilion has no real curators. (Unlike the adjacent Cosmonaut Memorial, it is controlled by the exhibition arm of the Soviet Union's National Academy of Sciences.)

In any case, the pavilion's visitors seemed less interested in scholarship than in space food and high-tech gadgetry. Displays of spacesuits and instrument panels generally garnered the most attention, and a steady parade of viewers filed past capsule portholes, debating the functions of the switches and gauges inside. To date only a handful of Soviet flights have been televised live, and the specifics of spaceflight rarely make it into print. For now museums are among the best sources of information about spaceflight available to the Soviet citizenry.

As I worked my way through the exhibits, I was struck by the immensity of the Soviet spacecraft. Massive rockets permit massive payloads, and it was clear that Soviet designers found little need for wholesale miniaturization of their creations. Far from being streamlined, most of the payloads bristle with projections, cables, and tubing.

Among the most fascinating objects on display was a model of Luna 24, an ungainly pyramid of white tanks and conduits that would have made Rube Goldberg envious. But

Barry Fitzgerald



A few young visitors are more intrigued by the wrong end of a telescope than by the spaceships around them.

Barry Fitzgerald

The image of a benevolent Gagarin dominates the Cosmos Pavilion, as befits his place in the pantheon of cosmonauts.

Luna 24 was a no-nonsense robot. In August 1976 it plopped down onto the moon, drilled six feet into the soil, and dashed back to Earth with its precious cargo. By then two other Lunas had already returned with moondust and at least two other attempts had failed. Officially, these missions duplicated the Apollo objectives without risking human life. Unofficially, they provided a means of saving face when the Soviets' plans to make their own footprints on the moon fell short.

The pavilion's rotunda is devoted to Soviet space travelers and the world peace that state propaganda says they promote. A huge inscription, "Cosmonautics: The Way to Peace," wraps around the wall. The theme is repeated often: in a huge portrait that dominates the rotunda, Gagarin holds a white dove. A model of Mir, the newest Soviet space station, was recently put on display—the name means both "world" and "peace."

For the Soviet Union, the Apollo-Soyuz (or, as the museum calls it, Soyuz-Apollo) Test Project was a natural extension of this doctrine. While Americans sometimes dismiss it as a glorified "handshake in space," the 1975 meeting of astronauts and cosmonauts in orbit is obviously considered much more in the Soviet Union. To recreate the linkup for museum-goers, a long-term exchange agreement has brought an Apollo capsule to Moscow and a Soyuz to the National Air and Space Museum in Washington.

During my tour of the VDNKh, I was able to achieve my own mini-linkup. As a blond tourist laden with camera gear, I was hardly inconspicuous, and an engineering student soon sought me out for a chance to practice English. Kolya yearned to fly in space, and he reasoned that choosing the right career and learning English would improve his chances.

As we chatted, Gagarin's portrait smiled down on us. Recently the Soviet Union announced an ambitious new plan to explore Mars, perhaps culminating in sending cosmonauts there early in the next century. That would mean new displays of hardware and portraits for the Cosmos Pavilion's galleries. But Gagarin's portrait will probably never be replaced. The first human in space serves as an enduring icon of the achievements reflected in Moscow's space museums.

Mark Milligan

An Eagle's Wings

Lieutenant General Frank Petersen is a Silver Hawk, a Gray Eagle, and the Marine's first black aviator.

by Tom Huntington

Frank Petersen earned his wings in October 1952 at the age of 20. When he accepted the commission as a second lieutenant in the Marines, Petersen entered the record books: he was the first black aviator in the history of the Corps.

Today Petersen is a lieutenant general, with three silver stars glinting on the collar of his crisp Marine uniform and his wings resting just above an array of service ribbons. He is the commanding general of the Marine Corps Combat Development Command in Quantico, Virginia, the "crossroads of the Corps" where all Marine officers are trained. He is a veteran of two wars, Korea and Vietnam. He is also the Gray Eagle, the active-duty Naval aviator with the earliest date of designation. Of all today's Naval aviators (including the Marines, which are affiliated with the Navy), nobody earned his wings before Petersen. Nobody, in fact, in any branch of the U.S. armed forces did. In the line

The F4U Corsair is one of Frank Petersen's two favorite airplanes. The F8F Bearcat is the other.

of military aviators that stretches from the grayest to the greenest, Petersen stands at the front.

At 56, the Gray Eagle is not all that gray—just a touch in his close-cropped hair. He is slim, with a long, serious face that occasionally lightens with a smile. Recently, while recovering from hip surgery to repair an injury suffered in Vietnam, he walked with a cane, but he didn't seem to depend on it very much as he moved stiffly but briskly through the corridors of Quantico.

Petersen is soft-spoken and articulate, his diction honed by years of military service into the formal, slightly stilted phrasing typical of the career soldier. As he sits talking in his office, he rests one immaculately polished black shoe on the edge of a coffee table. Placed on the table, perfectly aligned with its edges, are books about the Marines and a tome on military heraldry. The office is large, spacious, and above all neat.

You sense a slight wariness, a feeling that he won't reveal much of a personal nature. He politely declines to talk about his children, explaining that he worries about "kooks" being attracted by his high visibility at Quantico (at the time in the middle of the much-publicized Lindsey Scott rape trial, with its racial complications). Perhaps his reticence is also simply a result of his Marine background, which stresses discipline over candor. "The Marine Corps seems to be the number one force in terms of discipline," he says. "You don't find any first names used between junior and senior officers.... You'll find a Sergeant Major is called Sergeant Major, not Jim or Joe."

As a young man, Petersen began to get restless in his hometown of Topeka, Kansas. "Some of my friends had gone away earlier," he recalls, "and joined the Seabees and the Navy and had come back and given me a lot of stories about the great life out there. I had always desired to see the oceans and to get away from my home and see a little bit of the world."

His father, who owned a radio and TV repair shop, felt differently. He wouldn't allow his son to enlist, so Petersen entered college for a year. When he turned 18 he no longer needed his father's permission to sign up.

Petersen joined the Navy in 1950, only two years after the U.S. armed forces had been desegregated. Until President Truman signed Executive Order 9981, the military, like bathrooms, lunch counters, and buses, had been strictly divided into black and white. Black aviators had served with distinction in World War II, but not alongside white pilots. In the early years of integration the Navy was still not an ideal place for a black man to find an aviation job, and Petersen, who was unaware that blacks were even eligible for aviation training, wasn't looking for one: he enlisted with the goal of becoming an electronics technician. But the death of a black pilot he never knew changed his plans.

> Petersen had some sense of being a trailblazer, but he plays down the role.

Ensign Jesse Brown, the Navy's first black pilot, had been flying his F4U Corsair over Korea when he was shot down. He died while pinned inside his airplane, despite the extraordinary efforts of his wingman, who crash-landed and tried to free him.

"I was listening to a radio in my bunk in Navy boot camp and heard the story," Petersen recalls. He started inquiring about the aviation program. When he learned that the Marines had no black aviators at all, he decided to join the Corps.

Obviously, Petersen had some sense of being the first, of acting as a sort of trailblazer, but he plays down the role. "Well, 'trailblazer' sounds a little exotic," he says, "but I was aware of the fact that there was a paucity of blacks. I also was aware of the fact that there had never been an aviator, a black aviator, in the Marine Corps. So in that sense, yes, I guess you could use the analogy of being a trailblazer."

Racism—blatant and legal—was an ugly fact of life in the United States in the 1950s. Petersen also plays down the bigotry he encountered in the military, but he will talk about problems off-base. Just before he earned his wings at Pensacola, Florida, Petersen and another black cadet took a bus to Mobile, Alabama, for a party. "Blacks were supposed to sit in the back," he recalls. "But if the bus filled in the black section, then you were allowed to move forward to the white section by one row." Petersen and his friend did just that when they gave up their seats to an elderly black woman.

The driver stopped the bus. He would not go on, he said, until the two Marines moved back to the black section. They refused. The driver became threatening. When the Marines didn't budge, the bus driver called the police. "The shore patrol arrived first, and the Navy lieutenant put us in the back of a paddy wagon," Petersen says, "took us away from that scene, about two blocks away, stopped the paddy wagon, came around and told me, 'Frank, I know you're about ready to graduate. And you're just about to finish up. You don't need this. Keep your cool and you'll make it.' He let us out and we walked away."

Petersen tells the story dispassionately, matter-of-factly. If he still feels any anger, he doesn't show it. "You were dealing with two laws," he says. "If you went off the base you were dealing with the local laws of discrimination." On the base, which was governed by federal regulations, the situation was different—"There was ostensibly no prejudice and no discrimination," says Petersen. "And the weirdest thing was to be riding the bus back from town, sitting in the black section. As soon as it crossed the gate all of us would automatically stand up and walk to the front and sit in the white section. It's that kind of b.s., you know. Plus, you could not socialize with your roommates offbase. There was no place you could do that. So it was a little weird, very confusing. But that was the United States in the South in the '50s."

The Gray Eagle award dates back to 1959, when Admirals Charles Brown and George Anderson first discussed the idea of officially identifying the senior Naval aviator on active duty. Among the suggestions for the name of the honor was "Bull Naval Aviator"; finally "The Venerable Order of the Gray Eagle" was chosen. Two aircraft com-

panies offered to sponsor the award and the Navy chose Chance Vought. Vought constructed a trophy featuring a solid silver eagle grabbing an arresting cable on a rough representation of a carrier deck. Engraved on the side of the trophy were the words "In recognition of a clear eye, a stout heart, a steady hand, and daring defiance of gravity and the law of averages." Each Gray Eagle has his name engraved on the trophy.

Petersen became Gray Eagle number 36 last August, when Vice Admiral James E. Service retired. He was already the Marines' equivalent, the Silver Hawk. He takes special pride in the honors—"In fact, I feel better about that than some of the other things that have happened in my career," he admits. And Marine/Navy rivalry being what it is, "I feel even stronger about the fact that now a Marine holds a Navy title as well."

Each February the United States celebrates Black History Month, and not surprisingly, Petersen—who is also the first black to command a Marine squadron—is in great demand as a speaker. He has—reluctantly, he says—become a role model for young blacks. He has been there, he has broken through many of the barriers, and he can provide encouragement that he rarely got when starting out.

Last February Petersen spoke at NASA's Black History Program, hastily rescheduled after a conflict with Washington's parade for its Superbowl champions. The date change took its toll: NASA administrator James Fletcher had to leave early, as did Melvin Bradley, a special assistant to President Reagan. But before leaving, Bradley told a story of another occasion, a program in which the woman running the show introduced Petersen by talking about his awards—the Distinguished Flying Cross, the Purple Heart, the Air Medal, and the Navy Commendation Medal, among others. She recounted all his combat experiences. "She finished a long litany," Bradley recalled, "then said, 'All that really means is, he ain't scared of nothing.' "

As far as accuracy goes, though, the line falls short, at least according to Petersen. He has doubts about fliers who say they're unafraid of combat. "For those who say they are, they're idiots. Braggadocio and swagger just do not exist in a true combat outfit," he says. "I guess the best way to sum it up was, What was your worst combat mission? And it would be the last one and the next one."

Petersen's worst was over North Vietnam on September 10, 1968. A lieutenant colonel at the time, he was leading a squadron of F-4 Phantoms when his airplane was hit. Flying across enemy territory, one engine gone and the other going, Petersen was desperate to get back over safe territory before he and his backseat man bailed out. They made it, but Petersen was slightly battered by his ejection. And, the story goes, he flew 200 more missions before receiving medical attention.

"Well, that reads good in print," he says. "When I punched out I did receive some damage. I suffered a herniated disk in my back and a hairline fracture in my left hip, neither one of which manifested itself until after I left Vietnam some eight months later . . . . It wasn't until I returned to the States that I realized that there was something really wrong with me." Petersen won't encourage a story of a pilot who flew all his missions despite injuries and tremendous pain.

Frank Petersen has had an exemplary career: brigadier general in 1979, major general four years later, lieutenant general in 1986. He has also found time to get bachelor's and master's degrees from George Washington University in Washington, D.C. He does regret that his career has not left him enough time for flying. "If you're really a dyed-in-the-wool airplane driver you'd like to spend as much time as possible in the cockpit," he says. "And over the years I think of various staff assignments that I think if I'd fought a little harder I could have avoided. But if I were to do everything over, I think I would try and spend a hell of a lot more time in squadrons as opposed to staff billets." But, he concedes, "it's pretty hard to do in the Marine Corps."

When he speaks of flying, Petersen begins to sound genuinely excited. "Once you're bitten you just never get rid of it," he says. "It's just a part of you, especially if you're in a tactical squadron where you match your skills, physical skills, against another pilot."

But when Petersen retires in July, with 36 years as a Marine behind him, his flying will be . . . well, less exciting. "The saying is there's no old, bold fighter pilot," he says. "I'll say there's no old fighter pilot." About two years ago Petersen went up in an F-4 for simulated combat with some of his troops. "And I'll tell you, when I climbed out of

The Gray Eagles

Admiral C.R. Brown had been the Navy's senior aviator for nearly a year when in 1961 he became the first official Gray Eagle. The trophy also includes the names of Brown's predecessors who would have been Gray Eagles, including the Navy's first aviator, Theodore Ellyson. Following are the Gray Eagles, and the dates they attained the title.

Frank Petersen is Gray Eagle number 36.

USMC

Cdr T.G. Ellyson
June 2, 1911

Adm J.H. Towers
February 27, 1928

VAdm G.D. Murray
December 1, 1947

Adm D.C. Ramsey
December 1, 1947

Capt H. T. Stanley
May 1, 1949

Capt W.W. Townsley
August 1, 1951

Capt A. O. Preil
July 1, 1955

RAdm I.M. McQuiston
January 1, 1959

VAdm A.M. Pride
July 1, 1959

VAdm T.S. Combs
October 1, 1959

Adm C.R. Brown
April 1, 1960

RAdm F. Akers
January 2, 1962

USMC

the cockpit I knew that that would be about the last time. I was tired. These guys wanted to go back out again. I said, 'Okay, we'll try once more but after that, uh-uh.' I was through."

Being the commanding general of Quantico doesn't leave much time for flying anyway. Much of the job is administrative work, and escorting VIPs—Washington is just a half-hour away—around the base. At a weekly staff meeting in January the talk was mainly of the mundane: street lights, on-base schools for the Marines' children, financial reports. Through it all Petersen sat, stroking an eyebrow with one long finger, staring at the ceiling, occasionally asking a question or cracking a mild joke. The feeling was one of routine, and the *thwop-thwop-thwop* of choppers outside and the ribbons on the uniforms in the room only hinted at the adventure and excitement that persuaded a young black man from Topeka to join the Navy 38 years earlier. ✈

Petersen will retire this summer, but he plans to continue flying as a civilian.

RAdm W.M. Beakley *April 1, 1963*	RAdm R.J. Stroh *July 31, 1968*	Adm N. Gayler *August 29, 1975*	Adm M.F. Weisner *June 30, 1979*
RAdm R. Goldthwaite *December 31, 1963*	RAdm G.P. Koch *November 28, 1969*	RAdm M. Carmody *August 31, 1976*	LGen A.W. O'Donnell *October 30, 1979*
LGen R.C. Mangrum *October 1, 1965*	RAdm A.R. Matter *July 31, 1971*	RAdm G. Cassell *May 27, 1977*	VAdm R.F. Schoultz *June 26, 1981*
VAdm F. Lee *June 30, 1967*	RAdm F.D. Foley *February 29, 1972*	CWO H. Wildfang *August 31, 1977*	VAdm C.J. Kempf *February 25, 1987*
Adm C.D. Griffin *July 31, 1967*	Adm T.H. Moorer *June 29, 1972*	MGen F.C. Lang *May 31, 1978*	VAdm J.E. Service *June 5, 1987*
VAdm A.S. Heyward *February 1, 1968*	RAdm L.V. Swanson *June 27, 1974*	LGen T.H. Miller *June 30, 1978*	LGen F.E. Petersen *August 21, 1987*

Wanted: Pilot. Immediate Opening.

The big white plastic box housing the Boeing 727 simulator reared up on its mechanical haunches, shuddered, and pitched forward as its crew recovered from a stall. It bore a striking resemblance to one of the Imperial Walkers in *Return of the Jedi*—you could picture an avalanche of logs tripping it up and sending it sprawling, legs entangled, to lie helpless on its side in the concrete pit.

I watched from the balcony, awaiting my session at FlightSafety International's Louisville, Kentucky Learning Center—one of 30 that provide simulator training for airline, military, NASA, and business aircraft pilots. I was there to indulge—harmlessly, I hoped—a common fantasy of light airplane pilots: you're in seat 25D, 30,000 feet over Kansas, when a flight attendant rushes up and begs you to take over the controls. The crew can't fly—food poisoning—and you must call on your 150 hours of experience flying airplanes so small they'd fit in the airliner's baggage hold. You're the only one with the remotest chance of landing this hapless 727, full of nuns, sick children, and the Toledo Mud Hens farm team.

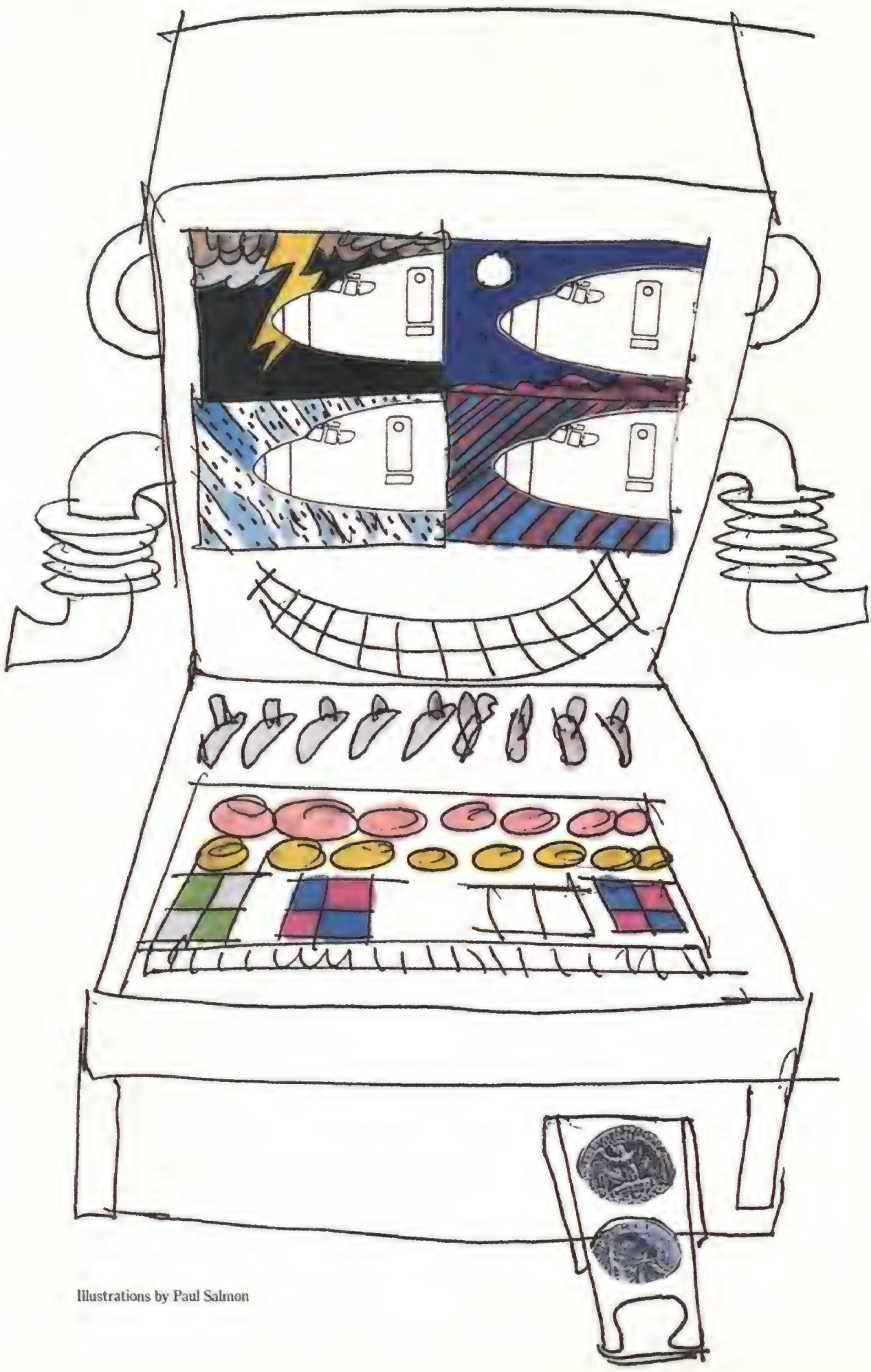
As the simulator clacked and whirred, I told myself it would be just like playing a video game—albeit a costly one. Two hours in a $10 million simulator would eat up an awful lot of quarters.

"Brad Berg will be your instructor," the FlightSafety public relations man had said. "He's an old TWA hand." Captain Berg started in DC-3s, finished in 747s, and logged about a billion hours along the way.

"There's a 727 instrument panel chart around the corner," Berg said while we waited for my time slot. "Want to study it?"

"No, I have to go into this cold," I said. "That would be cheating." Just then the crew with the stall problem came trudging down the hall, pale, damp, and exhausted. "C'mon, let's have some fun," Berg said gleefully.

The CAE Electronics B727-212B simulator provides 13 airport scenes in night, twilight, and low-light day visibilities through four video screens bolted to the cockpit windows. Berg chose Los Angeles



Illustrations by Paul Salmon

International, night. I climbed into the left seat and Berg got into the right. Instructor Jim Angelcyk settled in at the flight engineer's station and programmed the flight to begin at 20,000 feet.

I dutifully buckled my seat belt—earlier Angelcyk had recalled a session during a thunderstorm, when lightning had zapped power lines and sent a pulse through the simulator's gray matter that set the box pitching wildly on its spindly legs. The crew got bounced around like ice cubes in a cocktail shaker and the pilot ended up with a broken collarbone. "This thing can get up to about three Gs," he warned.

"Okay, here's the deal," Berg shouted over simulated wind noise. "You've just been brought up from the cabin. The cockpit is empty. What do you do?"

That was easy—I'd seen *Airport* and its dreadful sequels. "Make sure the airplane is in stable flight," I said, searching the panel for a familiar face among what seemed like hundreds of gauges and instruments, all glowing a muted, accusing red. A bouquet of throttles sprouted between the seats; at the base of the console a paddle switch indicated the autopilot was in control. I thought back to Hollywood's method of dealing with this sort of emergency. "Okay, now I call Air Traffic Control and ask for help, right?"

Berg, playing a 727 pilot in an approach control facility trying to talk me down, called out the location of instruments for airspeed and altitude and the flap and landing gear handles.

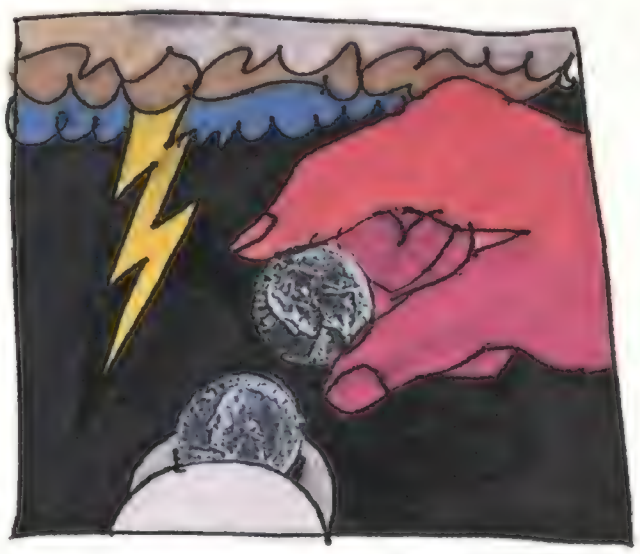
I had imagined the controls would match the airplane's size: a control column like a redwood, a yoke a few yards wide, rudder pedals like sleds. But the cockpit was almost cozy. "It looks like . . . well, kind of like a little airplane," I told Berg. "An airplane is an airplane," he said. "If you don't think about what's attached to the cockpit, you won't get too intimidated." My confidence rose. "But today, there's 130 people back there counting on you," he added.

Berg fed me instructions on setting the proper instrument landing system frequency on the navigation radio, banking the airplane side to side by tweaking the autopilot turn knob, and reducing power as the autopilot flew us toward LAX's Runway 25 Right. "Shouldn't I be doing something?" I asked, feeling useless. "Nope," said Berg. "The autopilot will intercept the glide slope for you when you're close enough. All you're going to have to do is put down gear and flaps and disconnect the autopilot—see the switch under your left thumb?"

"Yeah, I got it."

"DON'T TOUCH IT until I tell you to. Then you'll pull back on the yoke until your attitude indicator reads five degrees nose-up. Then you'll touch down."

This wasn't quite the drama I had hoped for. At 220 knots I got to extend the flaps—two degrees, then five, 15, 25, 30. Next, I put down the landing gear with a sweeping, purposeful *chunk* of the handle, and the wheels (the computer, actually) replied with a reassuring *thunk-thunk*. "You can go ahead and preset the brakes," Berg said. "There's a switch over the



centerpost." The placard read MIN MED MAX. "Set it to max."

I sat idle again until we were over the runway, when Berg announced it was time to switch off the autopilot and bring the nose up to slow the descent. Seconds later the wheels touched the runway—main gear, then nose wheels—and the tires clunked rhythmically over the ridges in the concrete. "You did it!" Berg said.

"No, the autopilot did it," I said. "A chicken could have landed this thing." I had hoped to have a better story to tell at the office the next day, one in which a major airline or maybe even the Air Force signs me up on the strength of my remarkable simulator performance.

"All right then, you hand-fly the next one," Berg said, and turned off the autopilot. Angelcyk reset the software to drop us off over Los Angeles again. A computer-generated full moon bobbed up—*sproing*—then a few stars, and the symmetry of LAX reappeared below. A minute into our electronic ascent I glanced up and saw the entire city tilting by at 500 feet. "Don't watch," Berg warned. "You'll get all fouled up." "It's just the software," Angelcyk said. "Here, I'll add cloud cover." He punched a few buttons.

At 20,000 feet Berg cut off the autopilot. "It's all yours." I had a death grip on the yoke—the Mud Hens were counting on me. "Here, try following the flight director command bars," Berg suggested, pointing out a gauge with an airplane symbol below a V-shaped bar. "Put the nose in the center of the V and keep it there, and you'll fly right to the runway."

"Flies just like a little airplane," I told myself, but the response time was much slower. I ended up stumbling down the glide path, trying to force the airplane around the dance floor and stepping all over its toes instead of following its subtle lead. If you want to turn NOW you should have started a paragraph ago. Same thing with the throttles; at idle, there's a lag of about five seconds between the time you ask for full power and the time you get it.

My approaches started to unravel five miles out. And the lower we got, the more often the mechanical voice of the ground proximity warning system dolefully intoned, "Pull up WHOOP WHOOP Pull up WHOOP WH—" "Oh, shut up," Berg said, pulling the circuit breaker after one too many interruptions. By the time we reached the runway threshold I had the airplane either heaving up and down like the *Bounty* in a gale or waltzing back and forth across all four runways.

"Excuse me," said Berg. "Which one do you plan to land on?"

"None, I guess. Let's go around."

Berg turned off the flight director for my fourth and final approach and for some reason I flew better without it. One mile from touchdown: runway dead ahead, a broad, welcoming, and—at last—stationary expanse. Berg squirmed in his seat, using body English to coax me to a decent landing. "You got it this time, you're good, don't forget to fl—" *KABLAM.* Mesmerized by the lights, I flew into the runway like a bird hitting a picture window. I had neglected to flare—a simple business of pulling back on the yoke just before touchdown. But Berg, ever the gentleman, said only, "Good job. I've seen worse."

We had 15 minutes left. "Okay, what next?" Berg asked.

"Let's roll it."

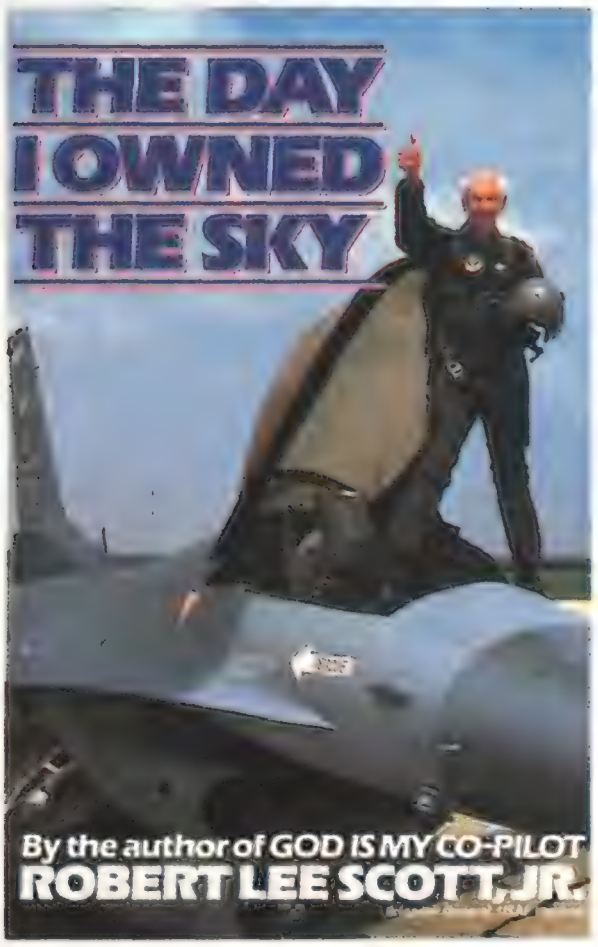
"What, you want me to lose my job?"

"I won't tell anyone."

"Yes you will." Instead, Angelcyk programmed in thunder, lightning, heavy rain, turbulence, and hail, through which Captain Berg flew flawless approaches with one engine out.

We walked out to the parking lot, squinting like bats in the afternoon sun and still shouting from the din of simulated hail. I asked Berg what he really thought the chances were of a light airplane pilot landing an airliner. "It *could* be done, I suppose," he said cautiously. Then he grinned and lowered his sunglasses. "But I wouldn't put my money on you if the autopilot was out."

—Patricia Trenner



The Day I Owned the Sky *by Robert Lee Scott, Jr. Bantam Books, 1988. 238 pp., b&w photos, $17.95 (hardbound).*

Who is Robert Lee Scott?

The average bookstore browser will probably wonder when he runs across this modest, anecdotal autobiography, but no aviation enthusiast will. Scott is the author of *God Is My Co-Pilot,* the 1943 account of his adventures as a fighter pilot that has since been read by every teenager longing to follow Orville and Wilbur into the wild blue yonder.

Now 80 years old, Scott was America's first certified air ace of World War II. He shot down 22 Japanese aircraft over China and was ordered home while still in one piece so he could be paraded before factory workers and civic groups across the United States. The Army Air Corps' publicity department pulled out all the stops, making him a media star before the phrase was coined.

In his new book Scott tells how he dictated *God Is My Co-Pilot* in three days between speaking engagements, and how General Hap Arnold detailed him to Hollywood as a technical expert when the movie of the same name was made. The film was one of those flag-waving potboilers that doesn't even run on the late late show anymore, but the book remains a classic of aviation literature. It's been continuously in print since 1943.

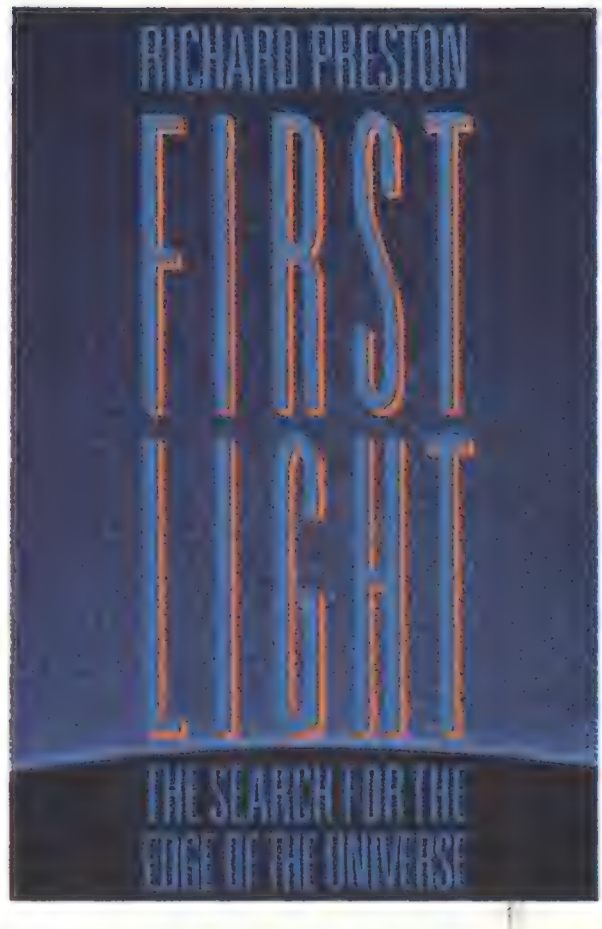
The Day I Owned the Sky is not your average autobiography. It is not a careful account of a colorful military career, and it does not contain thoughtful portraits of the many VIPs Scott met along the way, people like Claire Chennault, Curtis LeMay, George Bush, the Queen of Greece, and a pope or two. Rather, it is a collection of reminiscences, a look back by a man who lived his entire life as an adventure.

After retiring from the Air Force in 1957 as a brigadier general, Scott began a new career on the rubber chicken circuit as a hired raconteur. Mercifully, he says little about those days. Instead he devotes the last half of the book to his efforts to complete a lifelong quest: retracing the journey of Marco Polo from Venice to China. This story makes the book worth reading.

In 1980, at 72—an age when most define exercise as a hike around the block—Scott set off to complete his journey from Pakistan to Beijing (in the summer following his graduation from West Point he had motorcycled the Venice-to-Pakistan leg). As a by-the-way, he planned to travel the entire length of the Great Wall of China. A lot of the wall has eroded away in the centuries since the Ming dynasty, but Scott walked all the remnants, from the Gobi Desert to the Yellow Sea.

In these pages we meet the real Robert Lee Scott. We see the determination that made him an air ace and the love of life that has kept him so active all these years. A great writer he is not, but his China odyssey is told from the heart.

—Stephen Coonts, a former Navy attack pilot, is the author of the best-selling novel Flight of the Intruder.



First Light: The Search for the Edge of the Universe *by Richard Preston. The Atlantic Monthly Press, 1987. 263 pp., $18.95 (hardbound).*

An explosive, flat-faced, blue-eyed Bulgarian raised in Switzerland, Fritz Zwicky repeatedly scandalized the diners at Caltech's Atheneum dining room by throwing himself on the floor and challenging everyone to one-armed pushups. His colleagues already knew what he thought of them because he called them "spherical bastards"—spherical because "they are bastards every way I look at them." Once, on Palomar Mountain, Zwicky asked a night assistant to fire a rifle along the Hale Telescope, claiming that the bullet would drill a hole through the air and thereby improve the seeing. He ended his days in an office in a Caltech basement, among the graduate students, now and then bellowing "Who in the hell are you?" at passersby.

Bull-moose-at-large in a profession in which the plums go to the sleek, Zwicky

nonetheless discovered the missing mass that binds the galaxies. With the timid Walter Baade, he also discovered the existence of supernovas (the two of them coined the word). As author Richard Preston observes, he was a "maximal space freak." I find Zwicky the most vivid of the assorted eccentrics lovingly displayed in *First Light,* but I am biased: when I first got hooked on astronomy, one of the bits of esoterica that fired my imagination was a star called One-Zwicky-One, and I am delighted to know how it earned its name.

Preston unforgettably portrays the people behind the Palomar telescopes—those who created them, loved them, and loved the universe through them. If the universe is weird beyond imagination, so is this generation of telescopists, not only *genii loci* (the locus being Palomar Mountain) but *genii foci*, addicts of Palomar's Big Eye (the 200-inch Hale Telescope), Little Eye (the 18-inch Schmidt, in a thicket of oaks, on which Zwicky worked), and Medium Eye (the Schmidt 48-inch). Anyone who dotes on telescopes will get a thorough emotional workout from the pages on Palomar hardware.

But the wonders of Palomar, and of the infinite universal depths captured in them, have a hard time competing with the personalities Preston draws. There was prototypical project director George Ellery Hale, who used to jog up Mount Wilson reciting Italian poetry, suffered from a whole constellation of ailments (headaches and insomnia among them), took career advice from an imaginary elf, and spent his last years in an underground chamber peering at images of the sun without ever once going to look at his greatest telescope up on the mountain. Lens-grinder Bernhard Schmidt blew off his right arm with a pipe bomb of his own design at age 11, survived a World War I prison camp, worked on his lenses wearing tails and striped trousers, and killed himself with cognac so as to avoid the second world war.

A more recent generation of astronomers and gadgeteers shows up in the book, though they too tend to be overshadowed by their predecessors. The most captivating of the current group is Maarten Schmidt—no relation to Bernhard, except as a fellow visionary. Maarten discovered quasars in 1963 and, as Preston writes, "after several years of photographing quasars alone in the prime focus cage of the Hale Telescope . . . had smashed open the universe, had driven the limits of the Hale Telescope into territory beyond anything its builders had imagined, identifying quasars at greater and greater leaps, plunging into lookback time." Tall and dapper, he sports a red shirt and a yellow scarf, still carries a green card (he's Dutch), and when he has time heads for a resort in Southern California's Anza-Borrego Desert, where he and his wife lounge under a palm tree and view the stars through binoculars. Other luminaries here are James Gunn, the myopic fix-it man of Palomar who converts junk into gadgets of genius; Carolyn and Gene Shoemaker, who discover and collect asteroids the way others collect gems or antiques; and Juan Carrasco, an ex-barber who operates the fragile Hale Telescope for its astronomers.

Preston's prose is sometimes a bit wooden ("Baade squinted into the eyepiece. Baade noted . . . ") and he likes to start sentences with "He." There are also some unnecessary repetitions. His heart is in the right place, though. He has brought in from the cold of the observatory to the comfort of our armchairs scores of marvels, from the Zwicky Antennae, the Draco dwarf, the Pavo-Indus region of galaxies, and Stephan's Quintet to mini-planets called Pittsburghia, Mildred, Rumpelstilz, Swissair, Retsina, Bistro, and Evita, Descamisada, and Fanatica (the last three for Eva Peron).

I am reminded of one of the Hopi Indians' kachina figures, *Mastop.* The Pleiades and the Big Dipper are drawn on *Mastop's* face; several white handprints on the doll's black torso symbolize the human touch on the universe. This cosmic handprint is exactly Preston's theme.

—Paul West's most recent books are Sheer Fiction *(essays),* Rat Man of Paris, *and* The Universe, and Other Fictions. *His next novel appears this fall.*

***The Art of Hot-Air Ballooning** by Roger Bansemer. Gollum Press, 1987. 165 pp., color illustrations, $34.95 (hardbound).*

Florida artist and balloon enthusiast Roger Bansemer's first book is dominated by richly colored paintings and sketches. The text is a hand-scripted running commentary that wraps around the illustrations. Warm and personable, it quickly establishes an intimate tone. Bansemer shares his thoughts on ballooning and balloonists with disarming openness; all but the most cynical are likely to be won over.

***Airburst** by Steven L. Thompson. Worldwide, 1988. 382 pp., $3.95 (paperback).*

Each book in Steven L. Thompson's Max Moss adventure series is based on some facet of advanced military technology. In *Recovery,* it's an airplane control system that is directly linked to the pilot's brain. In *Countdown to China,* spy satellite imagery is the key to a complex series of events that entangles a U.S. president in a Soviet war plan. *Bismarck Cross* finds the heroic Moss dealing with advanced missiles of the type that are now figuring in the U.S.-Soviet arms reduction debates.

In *Airburst,* Thompson introduces a subject he wrote about in *Air & Space/Smithsonian*: the computer-generated virtual world of the future cockpit ("The Big Picture," April/May 1987). Thompson's imagination and extensive research reach farther in this book, and he treats a much-discussed dilemma—terrorists threatening the United States with a stolen nuclear weapon—in a new and disquieting way. Thompson places the weapon in a small twin-engine airplane controlled by fanatics who have discovered that the relatively open skies over North America pose little challenge to anyone bent on destruction. It's difficult to find any technical flaw in the nightmarish scenario of *Airburst,* and that's just what may make it a controversial novel, particularly in the city marked as the terrorists' target: Washington, D.C.

—George C. Larson is Editor of Air & Space/Smithsonian.

***Flights of Passage: Reflections of a World War II Aviator** by Samuel Hynes. Frederic C. Beil/Naval Institute Press, 1988. 270 pp., $16.95 (hardbound).*

Samuel Hynes, a former Marine Corps dive-bomber pilot who now teaches literature at Princeton, has produced the ideal aviation memoir. *Flights of Passage,* his chronicle of coming of age in wartime, brings to life not just the pilots of an era but also the airplanes they flew.

With deft portraiture, Hynes recalls the air cadets who trained alongside him at Navy flight schools from Texas to Florida in 1943 and '44. His squadron mates included Ike, a country boy who "always spoke as though his mouth was full of water," and T, who "carried his shoulders hunched forward, and his head slightly on one side, as though he had been interrupted in a shrug."

Hynes' talent for characterization

extends to groups as well. He divides his fellow bomber pilot trainees into two camps, the Sanes and the Crazies. The Sanes, a faction that included the author, flew "because we liked to, but also flew to stay alive." The Crazies, Hynes speculates, were frustrated fighter pilots. They thrived on "the troubles and turmoil that we spend our lives avoiding" and indulged in suicidal antics such as "flathatting" down local highways—flying so close above the road that terrified drivers could make out "the streaks of oil along the bomb-bay doors."

The aircraft in which Hynes learned to fly emerge from these pages with equally quirky distinction. The Piper Cub trainer, for example, seemed "forgiving" of the abruptness with which novices returned it to the ground. The TBM torpedo bomber resembled a "pregnant turkey" and, unlike other airplanes, failed to shed its ungainly aspect when it took to the air. But what the bomber lacked in style it made up for in strength. Its weight, stability, and power made the TBM "marvelous for precision flying," writes Hynes. "If you were any good you could put your plane two feet from another one and stay there all day."

Rare is the pilot who can give groundlings such a vivid sense of what it is like to fly; Saint-Exupéry comes to mind. "Once you are really flying," notes Hynes, "it is the world that tilts, not the plane; it's the horizon that tips up when you turn, and settles back when you roll out, sinks when you climb, and rises when you dive."

As Hynes became an officer and an airman, his recurring dread was that he might fail some facet of "the Test," his term for the twin trials of sex and combat. Hynes' fears proved groundless on both counts—he married T's sister and flew more than 100 missions against the Japanese—but he relates his initiation into each domain with honesty and humor. Here, for example, is the untraveled Hynes, contemplating sex as a journey of exploration: "Girls were Africa and I was Stanley. Which way to the Congo? And what did you do when you got there?" Later, as the author sees action of a different sort in the Pacific, he describes the sensation matter-of-factly: "I had been hit, that was all. Not as dramatic as losing your virginity, not even like a first drink; just four or five holes the size of quarters in the smooth dark metal."

Flights of Passage appeals on several levels. It is a compelling record of combat, a candid look at the first years of marriage, and a vivid re-creation of the transcendent experience of learning to fly.

—Allan Fallow is an editor at Time-Life Books.

Credits

Cover. Illustrator Ron Miller, who specializes in space subjects, was one of six American artists who exhibited their work in Moscow for Sputnik's 30th anniversary.

Handling Charge. Edwards Park, a former fighter pilot, is a frequent Flights & Fancy contributor.

A Night in the Barrel. Daniel E. Moore Jr. has flown the F/A-18, F-14, A-7, A-4, A-3, and E-2. He is working on a book about modern carrier aviation.

The Black Box. Patrick Cooke has written for *Hippocrates, Rolling Stone,* and *Science 86.*

Balloons Over Venus. Greg Freiherr is a writer and information analyst whose specialties are aerospace and medical technology. Last year he founded GFI, a Washington, D.C.-based consulting firm.

Wrong Way Corrigan Revisited. Phil Cohan, a former newsman and veteran of the Foreign Service, is a freelance writer living in Washington, D.C.

The Schneider Trophy. Air Vice Marshal Ron Dick is former head of the British Defence Staff in Washington, D.C. He will be an International Fellow at the National Air and Space Museum later this year.

Captain Adams and the Midnight Rangers. Steven L. Thompson's last article for *Air & Space/Smithsonian* was "Sweden's 'Flying Weapon.' "

Hover Story. John Grossmann, who lives in Jamison, Pennsylvania, has written for *Inc., Hippocrates,* and *Esquire.*

How many light bulbs does it take to fly a bicycle racer across the Sea of Crete? Frank Lowenstein's articles have appeared in *Technology Review* and *Sierra.*

Commemorating Cosmonautics. *Sky & Telescope*'s senior editor J. Kelly Beatty covers U.S. and international space exploration.

An Eagle's Wings. Tom Huntington is managing editor of *Air & Space/Smithsonian.* His last story for the magazine was "The Boss."

Wanted: Pilot. Immediate Opening. Patricia Trenner is departments editor of *Air & Space/Smithsonian.* She has never been any good at video games.

"The Satellite Sky" Update/7

These regular updates to **"The Satellite Sky"** chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

- Cosmos 1932 3-88 TT
- Cosmos 1935 3-88 PL
- Cosmos 1936 3-88 TT
- Cosmos 1938 4-88 PL
- Progress 35 3-88 TT

300 to 630 MILES

- Cosmos 1933 3-88 PL
- Cosmos 1934 3-88 PL
- Cosmos 1937 4-88 PL
- IRS-1A 3-88 TT
- San Marco D/L 3-88 KEPL

630 to 1,250 MILES

- Cosmos 1924-31 3-88 PL

21,750 to 22,370 MILES

- CS 3A 2-88 TAN
- Gorizont 15 3-88 TT
- PRC-22 3-88 XI
- Spacenet 3 3-88 KOU
- Telecom 1C 3-88 KOU

Additional satellites

300 to 630 MILES

- Transit 11 10-77 VAFB
- Transit 13 5-67 VAFB
- Transit 20 10-73 VAFB

21,750 to 22,370 MILES

- Fleetsatcom 1 2-78 KSC
- Fleetsatcom 2 5-79 KSC

KEPL denotes Kenya Platform, an Italian launch site off the coast of Kenya.

Deletions

90 to 300 MILES

Cosmos 1769 down 2-18-88

Cosmos 1881 down 3-30-88

Cosmos 1906 destroyed 1-31-88

Cosmos 1916 destroyed 2-29-88

Progress 34 down 3-4-88

SDI down 4-9-88

Launched but not in orbit

90 to 300 MILES

Cosmos 1915 USSR photo recon	1-26-88	down 2-9-88
Cosmos 1917-19 USSR navigation	2-17-88	down 2-19-88
Cosmos 1920 USSR photo recon	2-18-88	down 3-9-88
Cosmos 1921 USSR photo recon	2-19-88	down 3-4-88
Cosmos 1923 USSR photo recon	3-10-88	down 3-22-88

Inoperative but still in orbit

90 to 300 MILES

Cosmos 1646

300 to 630 MILES

Cosmos 1709
Cosmos 1759
Cosmos 1777
Cosmos 1782
Cosmos 1825
Metsat, 11-83

630 to 1,250 MILES

Cosmos 1823

21,750 to 22,370 MILES

Cosmos 1629
Cosmos 1700
Ekran 11
Ekran 12
Ekran 13
Ekran 14
Ekran 15
Fleetsatcom, 8-81
Raduga 7
Raduga 9
Raduga 12
Raduga 13
Telecom 1B

Correction

Rename Westar 6 (21,750 to 22,370 MILES) Westar 5.

To order "The Satellite Sky" Send $6 UPS Postage Paid to:
Satellite Poster
Air & Space/Smithsonian Magazine National Air and Space Museum
7th & Independence Avenue Washington, DC 20560

In the Wings . . .

Courtesy Elinor Smith

Smith Recalls Bellanca—In 1927, 15-year-old Elinor Smith was grounded for flying under bridges. In the same year, Giuseppe Bellanca's *Columbia* flew nonstop from Long Island to Germany. And one summer Sunday, the precocious pilot befriended the renowned aircraft designer. Bellanca made at least as strong an impression on the young Smith as he did on the nascent aircraft industry.

Fear of Flying—One adult in four is a fearful flier. Can these people be helped?

Passages—In an Air Guard unit based in Tucson, Arizona, some of America's oldest fighter jocks have their first encounter with the newest U.S. fighter.

Lighter-Than-Air Terminal—United Airlines calls its new facilities at Chicago-O'Hare Airport "the Terminal for Tomorrow." Helmut Jahn's design is impressive—but does it work?

Mark S. Wexler

Whither the U.S. Space Station?—NASA's manned space station is at least 10 years and $30 billion away. Entrepreneurs say privately developed alternatives, such as the Industrial Space Facility (below), can do some of the space station's jobs sooner and better.

TO A RADAR GUN THEY LOOK EXACTLY ALIKE.

Forget the fact that the car on the left is a legendary performance car. And that the one on the right is a wagon.

A radar gun doesn't notice minor details like that. It focuses on only one thing: speed.

And from that point of view, the Porsche 944 and the Volvo 740 Turbo Wagon look remarkably similar.

In fact, in repeated quarter-mile tests, they came up with virtually identical numbers—both in elapsed time and miles-per-hour. In 0-60 tests, the Volvo wagon actually came out ahead of the Porsche.* Which is no small feat for *any* car. much less a wagon.

It's no wonder *Road & Track* magazine called the 740 Turbo Wagon the closest thing to a five-door sports car.

Which all goes to prove that the Volvo 740 Turbo Wagon is something very rare indeed:

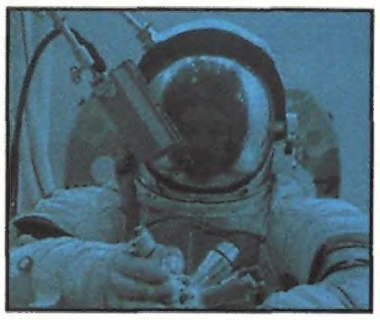
A wagon that's actually worth owning for what it packs up front.

VOLVO
A car you can believe in.

*BASED ON INDEPENDENT ACCELERATION TESTS.

HEADGEAR THAT HOLDS EVERYTHING AN ASTRONAUT NEEDS TO TACKLE SPACE MISSION PROBLEMS.

Keeping track of the millions of instructions needed to maintain a space station, monitor its systems and conduct research will be no easy task. But McDonnell Douglas space flight specialists have found a way to store massive amounts of data on computers linked to a miniature TV mounted on the astronaut's helmet. Detailed instructions needed to get the job done are instantly available at the touch of a button, leaving the astronaut free to move about the station and tackle intricate space mission tasks. Headgear data displays being developed by engineers at McDonnell Douglas–for spacecraft, aircraft and maintenance—save time and improve performance.



For more information, write: Data Display, McDonnell Douglas, Box 14526, St. Louis, MO 63178.

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Giving America its money's worth.

SPACE SYSTEMS HELICOPTERS DATA MANAGEMENT MISSILES COMMERCIAL & MILITARY AIRCRAFT FINANCING TRAINING HEALTH CARE